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ERRATA.

FEBRUARY, 1898.

Page 13, right-hand column, fourth line: read "The side branches effect an increased swing."

Page 16, right-hand column: leave paragraph preceding *Conclusions* out of consideration.

MARCH, 1898.

Page 94, Answers to Inquiries, No. 93: for "$BC = AB + BC$," etc. read "$AC = AB + BC$"; and for "OE is equal to BC" read "OE is equal to AC."

APRIL, 1898.

Page 101, right-hand column, line 27 from top: for "*The nature of the work*" read "*The nature of the road.*"

Page 139, Answers to Inquiries, No. 136, eleventh line from top: for "humped" read "bumped."

JUNE, 1898.

Page 235, Answers to Inquiries, No. 218, line 21 from top: for "40° C." read "– 40° C." Line 27 from top: for "AlO_3" read "Al_2O_3."

Page 235, Answers to Inquiries, No. 220, line 10 from bottom: for "Then, have" read "Then, hour."

JULY, 1898.

Page 277, Answers to Inquiries, No. 247, line 7 from bottom: for "30 horsepower" read "4 horsepower"; and on line 6 from bottom, for "100 horsepower" read "125 horsepower."

OCTOBER, 1898.

Page 429, Answers to Inquiries, No. 409, line 19 from bottom: for "generates 5,000 ohms" read "rings through 5,000 ohms."

Page 431, Answers to Inquiries, No. 418: for formula "$N = .0005236\,D$" read "$N = \frac{1906.99}{D}$."

NOVEMBER, 1898.

Page 483, Answers to Inquiries, No. 447: add "The number of turns in primary winding A should be $\frac{\sqrt{3}}{2}$ times that in primary winding C a B."

Page 486, left-hand column, line 8 from top: for "back" read "ahead"; and line 18 from top, for "rocker-arm ahead," read "rocker-arm back."

DECEMBER, 1898.

Page 496, right-hand column, line 15 from bottom: for "41,800" read "40,800."

Page 546, Answers to Inquiries, No. 512, section (*c*): for "ground exists on the wire" read "ground exists on the – wire"; section (*d*): for "2,000 feet" read "20,000 feet."

GENERAL INDEX.

PLUMBING.

POPULAR SCIENCE.

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ALPHABETICAL INDEX.

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HOME STUDY MAGAZINE

VOL. III.—No. 1. FEBRUARY, 1898. WHOLE No. 25.

SCRANTON, PA.

HOME STUDY MAGAZINE.

Vol. III. FEBRUARY, 1898. No. 1.

HOME STUDY MAGAZINE FOR 1898.

IN THIS, the first number of the third volume of HOME STUDY MAGAZINE, we wish to heartily thank our readers for the many evidences of appreciation that have reached us during the past year. Not only has the number of subscribers largely increased, but we have received many letters commending, in unqualified terms, the simple manner in which subjects relating to theoretical and applied science have been treated.

In the later numbers of Volume II we deviated somewhat from the policy with which we started out, by giving up the grouping (in two-number editions) of articles referring to a particular trade or profession. Then we reserved a page or two for articles on "The Cooking of Wholesome Meals." These will be continued in the present volume, and will be followed by others of interest to the good housewife. Another new departure has been the introduction of articles on the most interesting events of the day, under the title of "Current Topics."

During the past year the space devoted to answers to inquiries has been doubled. This section of the magazine has proved unexpectedly popular, and our only regret is that it has been impossible to find room for answers to all the questions sent in.

In one respect this number differs from its predecessors. There is no separate drawing-plate or special section devoted to mechanical and architectural drawing. In future, these subjects, together with machine construction and design, will be dealt with in the body of the magazine.

The object of HOME STUDY MAGAZINE is the same now as it was two years ago, namely, to give to practical men that knowledge of mathematics, physics, mechanics, and drawing which they must have if their efforts to improve themselves are to be successful. The articles are written *by* practical men *for* practical men, and are of special value to those who are interested in mechanical engineering, steam engineering, civil engineering, electricity, plumbing, heating, ventilation, building, architecture, or allied industries.

It will be our earnest endeavor to present every subject in its true light and in the simplest language, to make the explanations concise, yet full, and to point out always the practical usefulness of the information conveyed.

Premium to Every Subscriber: On page III the reader will find full information regarding a premium to which every subscriber to HOME STUDY MAGAZINE is entitled. It consists of a complete course of instruction in practical Free-Hand Drawing and Lettering, under the direction of the International Correspondence Schools, of Scranton, Pa.

We believe our readers will appreciate what this means. Every practical man knows that the ability to make a clear, readable, free-hand sketch is worth a good deal; he is too apt to imagine, however, that, just because he does not happen to be a born artist, it is impossible for *him* ever to do anything of the kind. This is a great mistake. *Any* one, if properly taught, can become proficient in making such free-hand sketches as are necessary to explain a mechanical contrivance or a design.

The premium includes an instruction book of 40 pages, nine comprehensive drawing-plates for the student to copy, and full and complete instruction through the mail.

NOTE.—For all information regarding HOME STUDY MAGAZINE see contents page.

begin the work anew, and reconstruct it from the very foundations, for it must be confessed that the fundamental principles underlying all our sciences are more or less hypothetic.

We have said that the science of mechanics begins when force is referred to and measured by its effects on external objects, that is, when it is defined in terms of external facts. What, then, is the physical effect of force? The ancients answered this question in a general way by saying that the effect of force is motion. We say "in a general way," because they were not concerned with the exact nature or amount of the motion produced; they conceived force as something that simply makes a body move, or disturbs the equilibrium of a body at rest. And here we have a further illustration of the origin of mechanical ideas; for the first thing with which experience makes us familiar is the moving of bodies by muscular effort; we do not pause to reflect on the velocity we impart to the body we lift, to the log we roll, to the peg we drive; all we are concerned with is the bare fact that we lift the body, roll the log, or drive the peg; it is nothing but breaking a state of equilibrium: beyond this the ordinary man of our day seldom goes, and the great mechanician of antiquity—Archimedes—never went.

The historical fact that mechanics began with statics is thus naturally explained. Statics is the science of equilibrium. In it force is conceived as either pressure or pull, and the motion caused by force is viewed as a disturbance of equilibrium, regardless of all other effects or circumstances. The mental process is simply this: it requires a certain muscular effort to disturb a certain state of equilibrium, and whatever disturbs that state of equilibrium is conceived as a force equivalent to the muscular effort, physically considered. Such being the case, the weight of bodies, regarded at first merely as their resistance to being lifted, at once suggests itself as a standard for measuring force. We have seen that the effort required to lift a body is (practically) the same as the effort required to keep it from falling; so that force, in its "tendency" to produce motion in one direction, may just prevent motion in the opposite direction. Here, then, we have the datum without which no exact comparison can be made—namely, *equality*. The "tendency of a body towards the center," that is, its *weight*, is a tendency to motion in a known direction, and any force that just prevents that motion we readily conceive as *equal* to the weight of the body.

The next thing is to devise an instrument, or apparatus, to measure weight, and a *unit* of weight that may serve as a standard to compare forces. For the measurement of weights, the simplest and oldest instruments are the pulley and the balance with equal arms. As for the unit, the weight of a piece of any material may be used. The piece is suspended from the arm of a balance, or at one end of a string passed around a pulley, and balanced by another body suspended from the other arm of the balance, or attached at the other end of the string passing over the pulley; then we have two units of weight. By balancing these two units we have four units, etc.

It may be worth repeating that weight is taken as a standard for the measurement of forces, not only because it produces in us the characteristic sensation by which all force is orignally known to us—the sensation of effort, but because it produces in other bodies the characteristic effect by which the physical nature of force is known to us—motion; and because any kind of action between bodies whose effect is motion may be replaced, in so far as this effect alone is concerned, by a weight. Or, taking the purely statical view of force, we may say that any state of equilibrium may be broken by the action of a weight, which is equivalent to saying that every force can be replaced by a weight. By the *magnitude* of a force is meant the weight that can replace it; so that, when we say a force is so many pounds or so many tons, we mean that a weight of so many pounds or so many tons will produce the same effect as the force.

Not having gone beyond the statical conception of force, Archimedes and his successors, up to the sixteenth century, left almost untouched the laws of motion, which in the mechanics of to-day play such an important part, not only on account of their theoretical value, but also, and perhaps more, on account of their practical value. This, however, by no means detracts from the greatness of the original investigators. They were treading almost virgin ground; they had no other teacher than nature, no other guide than their intellects, no other light than the light they themselves made; and they had to struggle with the traditions of an ignorant age, with their own inherited prejudices, and with the dogmatic errors promul-

gated in the majestic language of philosophy by such illustrious masters as Aristotle and Plato, the greatest of Greek thinkers. Archimedes is deservedly reputed the father of mechanics; he discovered the law of the lever, the laws of floating bodies and the properties of the center of gravity; while his mechanical contrivances were the wonder of his contemporaries, and still inspire us with admiration. The progress of man is a slow movement from the unknown to the known. We often, forgetting the origin of our knowledge, wonder at the ignorance of our predecessors, and can scarcely understand why they did not *see* facts and laws that seem to us self-evident. But this is a hasty judgment; there are no self-evident truths in nature. When we have become so familiar with a certain relation between facts that it is impossible for us to think of the relation being different from what it is, we say that the relation in question is a self-evident fact. History, however, teaches us that before this familiarity was acquired, many painful experiences, and often much profound thinking, were necessary; that many of the truths we regard to-day as axiomatic were brought to light by the prolonged study and the patient researches of the greatest intellects of our race; that mankind, like a child, began its journey along the route of progress with no knowledge whatsoever, and that knowledge, like all natural phenomena, is a process of evolution, whose effects, at first imperceptible, develop and multiply in something like geometrical progression. He who wonders at the ignorance of old times may be compared to him who wonders at the difference between the energy of a stone falling through a distance of one inch and an aerolite falling from the heavens: his very astonishment only serves to show that he has not yet become acquainted with the laws of nature.

At the present time our idea of force is perhaps as vague and indistinct as that of the ancients; but we have a clearer and more precise idea of its physical character, that is, of the external phenomena by which we define it. Motion, we have seen, is the external fact by which we know force; whence every motion, or, rather, every change of motion, is by us ascribed to the action of a force. Is there no relation between the nature of the motion produced and the magnitude of the force producing it? We readily see that when a force is applied to a body, not only the state of equilibrium of the body is disturbed, but the body passes to a state of motion, which can be clearly defined by measuring the space traveled by it in a certain time. The effect of a force on a body, then, is not only motion in general, but motion of a certain kind, measured by a certain velocity. Referring again to the example of heat, it will be remembered that when expansion was discovered to be the physical effect of temperature, the latter was measured by measuring the expansion produced. So, in the case of force, it seems natural that, once motion has been recognized as its distinctive effect, force should be measured by measuring the motion produced. This is the *dynamical* conception of force; it is the modern, and seems the most "natural" conception; yet it was many centuries before it was acquired; the science of motion is of comparatively recent origin. Here we are not concerned with the dynamical view of force; but we may remark, before closing this article, that the introduction of the new idea and of the new standard of measurement caused a complete revolution both in the world of science and in the world of industry. When there was no mechanics but statics, man might construct admirable structures—the pyramids of Egypt, the Roman aqueducts, or the noble edifices of Greece; and he might contrive some appliances for the transformation and transference of force, such as the war engines of antiquity. But the perfect machinery of to-day would be impossible if we knew nothing of the relations between force and motion—if we knew nothing of acceleration, momentum, work, energy, and other dynamical factors that enter as indispensable elements into the proper design of almost all modern mechanisms.

THE GAS-ENGINE.

E. W. Roberts.

Two-Cycle Engines—The Clerk Engine—Vertical Engines—A Valveless Engine—A Simple Mixing-Valve—Gas Versus Electric Light.

PART III.

NO SOONER had the Otto engine been placed upon the market than a host of inventors set to work to devise improvements, or, in some cases, simple modifications, in order to avoid conflicts with the Otto patents. One of the chief objections to the Otto cycle is that the engine employing it must be built four times as strong as a double-acting steam-engine of the same horsepower and running at the same speed, for the Otto engine gives but one power-impulse to the steam-engine's four. This circumstance led to the invention of the two-cycle engine, in which there is one impulse in every revolution. The first engine of this type (invented by Mr. Dugald Clerk), was put upon the market in 1880. Although it is no longer manufactured, it can truly be said to be the parent of the two-cycle type, and, as with the early Otto engine, a description of the Clerk engine is necessary before proceeding with the more modern types.

In Fig. 1 is shown a vertical section of the engine-cylinder along a line passing through the center. Fig. 2 is a similar horizontal section. Besides the principal or motor-cylinder *A*, the engine has an auxiliary cylinder *B*, with a piston *D*, Fig. 2.

The auxiliary piston *D* is attached by a separate crank to the fly-wheel of the engine, and this crank is so set that it reaches the end of its stroke just ahead of the motor-piston *C*. *I* is a slide-valve similar to that employed on the earlier Otto engine, but is used for the purpose of ignition only. This valve is operated by a bell-crank lever *b* attached to the spindle *g*, which is given a reciprocating motion by means of an eccentric on the crank-shaft. *F* and *H*, Fig. 1, are poppet-valves, both of which open upwards when subjected to the suction within the cylinders. Surrounding the lower valve *H* is a gas-channel *K* from which gas enters the space above the valve through a number of small holes in the valve-seat. At *Q* are "quieting" pistons, so designed that the valve is checked by an air-cushion when returning to its seat. This device does away with the disagreeable rattle which is so frequent an accompaniment to a poppet-valve engine. The water-jacket *J* surrounds the cylinder *A* and the compression-space *C*, as shown in the figures. No water-jacket is necessary for the auxiliary cylinder *B*, no gases being burned in it.

Fig. 1.

The following series of operations takes place in this engine: The auxiliary cylinder, or pump, first draws in a charge of air

through the valve *H*, which, as it enters, carries with it the required proportion of gas from the channel *K*. On the return of piston *D* the mixture is forced through valve *F* into the motor-cylinder *A*. Valve *F* opens just as piston *C* has passed the edge of the exhaust-ports *E*, *E′* and the pressure in the motor-cylinder has dropped below that in the pump. The ratio of the volumes of the two cylinders is so adjusted that the fresh mixture drives the greater part of the exhaust gases from the cylinder *A*, and yet no unburned gas escapes through the exhaust-ports. The piston *C* covers the exhaust-ports on its return, both cylinders compressing the charge until piston *D* starts on its forward stroke. Just as this occurs, the rush of gas from *A* into *B* closes valve *F*, and the compression is completed by the piston *C*. Ignition takes place immediately on the completion of the compression-stroke and the expanding gases drive the piston forward until they escape through the exhaust-ports.

The above is readily seen to be a clever modification of the Otto cycle, the pump doing the work of the suction-stroke and of the exhaust-stroke and aiding in compression. The pump is connected by the passage *W* with the space between the valves *F* and *H*. *L* is a gas-valve under the control of the governor; from it the gas flows to the gas-channel *K*. The valve *L* is so arranged that it closes just before piston *D* reaches the end of its stroke, so that the final portion of the charge is pure air. This is, of course, the first portion of the charge to enter the motor-cylinder, and the chances of fresh gas escaping through the exhaust-ports are reduced to a minimum.

The action of the ignition-slide will be fully explained in the next article on gas-engines. Owing to the greater frequency of the explosions in this engine, the Otto valve was not suitable. At *R′*, Fig. 1, is a relief-cock which is opened when starting the engine. It allows the gases to escape from the cylinder until the compression-stroke is half completed, in the same manner as the starting-cam on the Otto engine.

There are quite a number of engines on the market to-day using what is, practically, Clerk's modification of the Otto cycle. In the Robson engine the front end of the cylinder is enclosed, the piston having a rod with gland and stuffing-box, as in a steam-engine. The fresh charge is drawn into, and compressed in, the front end of the

Fig. 2.

cylinder much in the same manner as in the pump-cylinder of the Clerk engine. From the front end the charge is forced into a receiver at a pressure of about 5 pounds per square inch. As soon as the pressure within the motor-cylinder falls below that in the receiver, a new charge enters and drives the burned gases out through the exhaust-ports. The next, or return, stroke of the piston compresses the charge and draws a fresh mixture into the front end of the cylinder, which it discharges into the receiver during the expansion-stroke. This engine, as the reader will see, is quite similar in operation to the Clerk.

An ingenious engine, and one of which great things were expected, made its appearance in 1886. It is known as the Atkinson cycle engine and has, in addition to the ordinary valve mechanism, a link-motion so designed that the piston makes two long and two short strokes during each revolution of the crank-shaft. The charge is drawn into the cylinder by a short stroke beginning at the extreme back end of the cylinder. The gases are then compressed by a still shorter stroke, and, after ignition, expanded by a long stroke to greater volume than the mixture possessed at the end of the suction-stroke. The piston then returns until it reaches the *end* of the cylinder and all the exhaust gases are expelled. Theoretically, this engine produced an ideal cycle, but the

great difficulty lay in the maintenance of the link-motion. The engine never became a pronounced commercial success, and it was finally withdrawn from the market.

neared the end of the stroke a small piston-valve, operated through stem b' by the eccentric c, opens communication to a hot tube t, and the charge is ignited.

FIG. 3.

FIG. 4.

In Figs. 3 and 4 we have two sectional views of the Nash engine, a well-known modern representative of the two-cycle type. It is similar to the Robson engine in that it uses the end of the cylinder towards the crank for a charging-pump. But instead of using a piston rod and stuffing-box, this engine has its connecting rod and crank enclosed in an air-tight crank-chamber. Upon the upstroke of the piston a charge of gas and air is drawn into the crank-chamber. The succeeding downward stroke compresses the contents of the chamber, while a former charge is being expanded in the upper part of the cylinder. At the end of the stroke the exhaust gases escape through the exhaust-port e to the annular space E', and thence to the atmosphere through the pipe E. While the gases are escaping, the valve a is opened by means of the cam d operating through the valve-stem a' and a small roller on the end of a', the valve being held to its seat during the remainder of the cycle by means of the spring s. On a being opened, the fresh mixture drives the exhaust-gases ahead of it, and the cylinder is completely filled with the new charge. Compression now takes place, and when the piston has

At k a small governing-valve, attached to the governor by the lever m, controls the passage of the compressed charge from the crank-chamber to the working-end of the cylinder. The amount of charge entering the upper end of the cylinder is thus regulated according to the load on the engine, and an impulse of varying strength is given to the piston at each revolution, unless the load becomes so small that the valve k is entirely closed. A very steady-running engine is produced by the use of such a device, and an engine so governed is well adapted for driving electrical machinery, although its efficiency on light loads is decreased.

The heavy fly-wheel F stores up energy for compressing the charges and running the machinery during the intervals between the power impulses. The machinery is driven from a pulley P by means of a belt. Gas enters the crank-chamber through the valve g, the air-inlet and mixing-valve not appearing in the figures. Water enters the jacket at u and passes out at u'. The manner of lubricating this style of engine is shown in Fig. 4. At the bottom of the chamber is a layer of water which reaches up far enough

for the crank to dip in it at the lower end of the stroke. Oil floats on top of the water and is dashed over the reciprocating parts of the engine at each revolution, ensuring perfect lubrication. At *O* is an oil-cup for lubricating the piston, the surplus oil from which flows to the crank-chamber below. The ignition-tube is heated by means of the burner *f*. These engines are built in various sizes from ½ to 200 horsepower, sizes above 10 horsepower being supplied with from two to four cylinders.

Gas-engines are so often placed in care of persons unskilled in handling machinery that it has been the aim of many designers to produce an engine with the fewest possible number of parts. There is no better example of what can be done in this line than the original Day engine, an illustration of which appears in Fig. 5. Strictly speaking, this engine consists of but four essential parts. They are the cylinder and the frame (one piece), the crank-axle and its attached pulleys and fly-wheel (one piece), the connecting-rod, and the piston.

The operation of the engine is as follows: On the upstroke of the piston a partial vacuum is produced in the crank-chamber *e*, and when the piston uncovers the port *h* a charge of gas and air enters the crank-chamber, the air from the pipe *n* and the gas from a governor-valve; this valve is not shown in the figure. On the return of the piston the mixed gas and air is compressed to about 4 or 5 pounds above the pressure of the atmosphere. Near the end of the stroke the piston passes the exhaust-port *g*, and, immediately afterwards, the port *f*, communicating with the crank-chamber, is opened, and the entering charge, striking against the deflecting-plate *i*, passes to the top of the cylinder and down again in the direction of the arrows, driving the exhaust gases ahead of it and practically clearing the cylinder of the waste material. On the return of the piston the charge is compressed as usual, and is fired at the proper moment by a hot ignition-tube inside the chimney *l*. The method of timing the ignition will be explained in a later article. It will be noticed that air is drawn into the crank-chamber from the base *k*, which it enters through the small holes to be seen at the right. This arrangement is for the purpose of quieting the air-current, since it enters the crank-chamber with a rush.

The production of a vacuum in the crank-chamber meant a useless expenditure of energy, and the engine was afterwards so modified that the air entered the chamber through a check-valve, the air and the gas being drawn in during the entire upward stroke.

An engine having a cycle in all respects similar to the Day is manufactured by the Sintz Gas-Engine Company. A side and an end elevation of the Sintz engine are shown in Fig. 6. The engine uses gas or gasoline with equal facility, and, as shown in the figure, the special features necessary when employing gasoline as a fuel are retained.

The piston carries a deflecting-plate, and the admission- and the exhaust-valves are arranged as in the Day engine, a poppet-valve check controlling the admission of the charge to the crank-chamber. This valve, which is of unique design, is shown in detail in Fig. 7. The connections for gas are shown in dotted lines, Fig. 6. The gas from the meter passes through the rubber gas-bag *g*, the valve *g′*, and the pipe *g″* to the mixing-chamber *M*, Fig. 7. The gas-bag acts as a regulator to equalize the flow of the gas into the mixing-chamber. Air enters the holes *h*, Fig. 6, and flows over the top of the cylinder through the brass cylinder-head casing *n*, downward through the pipes *Y* to the mixing-chamber *M*. By passing over the cylinder-head the air is heated, so that when using gasoline the oil is vaporized in the mixing-chamber by contact with the warm air. The valve *V*, Fig. 7, is raised by the suction of the piston during the filling of the crank-chamber and is closed by the spring *S* when the pressure in the chamber falls. When gasoline is used it is fed to the mixing-valve by means of the pipe *r* from a tank placed above the level of the engine. The gasoline flows first to the reservoir *R*, which regulates the flow of the oil. From the reservoir the liquid flows to the compartment *Z*, Fig. 7, from which it is

Fig. 5.

admitted to Z' by the needle-valve r', the opening of which is shown on a graduated circle A by the stationary pointer p.

The mixing-valve itself will be seen to have two seats; the larger valve-face V controls the mixture, while the lower face r opens Z', allowing gasoline to flow into the mixing-chamber M. The warm air from both sides of the mixing-chamber passes over the surface of the liquid, changing it into gas and carrying it, thoroughly mixed with the air, into the crank-chamber. The charge passes from the mixing-valve in the direction of the arrows past the butterfly-valve x, which is operated by the short crank a outside of the pipe. By opening and closing this valve the quantity of the mixture entering the engine may be increased or decreased. The crank a is attached to the governor G by the rod a'. Thus, the regulating mechanism is similar to that in use on the Nash engine. The governor is driven from the crank-shaft by the belt b.

The charge is ignited by electricity. The ends of the igniter-wires may be seen at $F F'$. This igniter will be fully described in Part IV of this series. Both the igniter and the water-pump P are driven from the same eccentric e. Water enters the pump at w, whence it passes through the water-jacket and is expelled at w'. E is the exhaust-pipe. The fly-wheels f have broad faces, so that either one of them may be used as a belt-pulley. The force-feed oiler o supplies a lubricant to the piston and the crank-chamber. The priming-cup c is used for charging the cylinder with gasoline after the engine has been standing idle long enough to get cold.

This engine is manufactured in twelve sizes, from 1 to 30 horsepower. Sizes from 4 horsepower up are built with two cylinders. The makers claim that the two-cylinder engine is a very satisfactory source of power for electrical purposes.

The latest adopted method of dynamo-driving marks a bold step in gas-engine practice, and speaks well for the improvements that have been made in gas-engine speed-regulation. The engine and dynamo are bolted to the same frame. The engine is of the four-cycle type, but has two cylinders so arranged as to give an impulse for every revolution of the crank-shaft. The dynamo-shaft is connected to the crank-shaft of the engine by means of a flexible coupling, which is provided with four long helical springs, through which the entire power of the engine is transmitted.

Any small irregularity of motion is taken up by the springs, and does not affect

Fig 6.

the dynamo. The governor regulates the amount of the charge, so that the engine receives an impulse every revolution, whether running heavy or light.

If, instead of burning gas in an ordinary jet and obtaining light in this way, we use the gas to drive a gas-engine and dynamo, much more light will be obtained. Figures present a more forcible illustration than a mere statement of this fact, as the following example will show. It is customary to assume that each engine-horsepower will furnish sufficient c ten 16-candle-power incandescent one 800-candle-power arc-lamp. I we are to use is 20-candle-power ga sumption per horsepower deliver dynamo will not exceed 18 cubi average working; 20-candle-powe 20 candle-power for each 5 cubic f burned in one hour in the ordina

burner; so 18 cubic feet would gi

= 72 candle-power. Thus, we gain an increase in illuminating power of 1.22 per cent. by using a gas-engine and a dynamo in conjunction with the incandescent light. In the case of the arc-light, however, the increase is enormously greater, more than eleven times as much light being obtained from the same amount of gas. It might be

FIG. 7.

as well to state in conclusion that these figures are by no means exaggerated, much better results being frequently obtained in practice.

GALVANOMETERS, AMMETERS, AND VOLTMETERS.

Herman A. Strauss, E. E.

FUNDAMENTAL LAWS OF THE ELECTRIC CIRCUIT—THEORY OF ELECTRICAL MEASUREMENTS. ELECTRICAL MEASURING INSTRUMENTS—COMMERCIAL MEASUREMENTS—CALIBRATION.

THE ELECTRICAL CIRCUIT.—That which interests us mainly in any electrical circuit is the strength of the current flowing therein and the value of the pressure causing that flow. By virtue of the pressure the current is not only caused to flow, but it is also enabled to overcome a certain obstruction which may be placed in its path, such as that constituted by what is called *electrical resistance*. The quantity of this electrical resistance which any current can overcome is, however, limited by the current pressure; that is to say, if a given pressure will force a certain current through a known resistance, then, if the pressure is reduced by one-half, it will no longer be able to force the same current through the same resistance. Experiment has proved that, with half the pressure, either one of two conditions is possible. These conditions are:

1. One-half the pressure will force the same current through one-half the resistance.

2. One-half the pressure will force one-half the current through the same resistance.

The relation is equivalent to saying that *the pressure is proportional to the current and to the resistance*. When any quantity is

proportional to two other quantities, it is equal to the product of the two quantities; so that if

E = electrical pressure, or electromotive force;
C = electrical current;
R = electrical resistance,

we may write,

$$E = C \times R; \quad (1)$$

from which formula we obtain, by transposing,

$$C = \frac{E}{R}, \quad (2)$$

and

$$R = \frac{E}{C}. \quad (3)$$

These three formulas (which will be referred to later by their numbers) give us, in terms of the other two, the value of any one of the three electrical quantities of a circuit. The relation expressed by the formulas was first discovered by Dr. G. S. Ohm, of Berlin, Germany, and is known as *Ohm's law*.

In this article we will confine our attention to direct-, or continuous-current circuits, for which Ohm's law holds *absolutely*.

Measurements.—All measurements of resistance, pressure, and current strength are based on Ohm's law.

The electrical engineer, in the practice of his profession, often finds it necessary to make numerous and daily measurements of this kind. To facilitate this work, instruments have been devised which can be quickly connected to any circuit, and which at once indicate, by means of a pointer moving across a scale, the exact value of the quantity to be measured in that circuit. These instruments indicate the conditions of the electrical circuit in a manner similar to that in which the steam gauge of a boiler indicates the condition of the steam circuit.

Current.—The *strength* of an electrical current is, in practice, measured by a unit which has been named the *ampere*, in honor of the French scientist, *Ampere*. Any instrument, therefore, which will measure the strength of the current in amperes, is called an *ampere-meter* (that is, a meter, or measure, of amperes). This word ampere-meter is often shortened to *ammeter*. In electrical manufacturing establishments particularly, and in practice generally, the latter designation is almost exclusively used.

Pressure.—The pressure, or electromotive force, of an electrical current is, in practice, measured by a unit which has been named the *volt*, in honor of the Italian scientist, *Volta*. Any instrument, therefore, which measures the pressure of an electric current in volts, is called a *voltmeter* (that is, a meter, or measure, of volts).

Resistance.—The resistance of any substance to the passage of an electric current is, in practice, measured by a unit which has been named the *ohm*, after the already-mentioned German scientist of that name. Instruments designed to measure ohms directly, have been constructed and are in extensive use in laboratories, or wherever exceedingly accurate measurements are absolutely essential. Two instruments of this kind are the *Wheatstone bridge* and the *ohmmeter*.

The practical electrician, however, rarely makes use of them. Measurements which are correct within one-fifth of one per cent. are near enough for him and are considered exceedingly good, and as there are both ammeters and voltmeters on the market, which give results approaching or even better than this, the practical engineer contents himself with *indirectly* determining the electrical resistance of any circuit by the use of formula (3).

According to this formula, the resistance is given by the quotient obtained, when the pressure of the circuit is divided by the strength of the current flowing therein. The method of procedure is, then, to measure the *voltage* of the circuit with a voltmeter, and the *amperage* with an ammeter. A simple calculation is then all that is necessary, namely:

$$\frac{\text{Volts}}{\text{Amperes}} = \text{Ohms}.$$

The use of the two instruments, the voltmeter and the ammeter, is, as a rule, all that the practical engineer requires for the various measurements of the electrical circuit.

Theory of Construction.—The most practical, efficient, and (within the limits stated above) the most accurate instruments in general use to-day, as ammeters and voltmeters, are those which rely for their action upon the effect which a closed coil, carrying a current, has upon a magnet; or—vice versa—upon the effect which a magnet has upon a closed coil, carrying a current.

A fundamental experiment illustrating this effect is shown by Fig. 1, in which a magnetic needle NS, is suspended on a pointed pivot which allows it to turn easily. Above the needle and parallel to it is a conductor carrying an electric current, the current flowing in the direction indicated by the arrow. Immediately this conductor is

brought into the position shown, the needle turns briskly aside, the *N* pole of the needle turning toward the east. If the conductor is moved, and held *below* the needle, the *N* pole of the needle at once turns in the

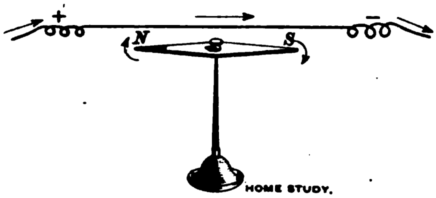

FIG. 1.

opposite direction, toward the west. These movements can be firmly fixed in the mind by the following rule, originated by Ampere:

To determine the direction toward which a magnetic needle will point when influenced by an electric current, imagine yourself swimming in the conductor, with the current; turn your body so as to face the needle, then the N pole of the needle will turn toward your left hand.

In other words, the deflection of the *N* pole of a magnetic needle, as viewed from the conductor, is *always* toward the left of the current.

Now it must be remembered that the magnetic needle, when not influenced by an electrical current, will point north and south, because of the directive forces of the earth's magnetism. Therefore, when a conductor, as above shown, is brought near the needle, the electric current in the conductor must overcome this tendency of the needle, and therefore the final position which the needle takes is a resultant of two forces, namely, the earth's magnetism and the current in the conductor. If the latter

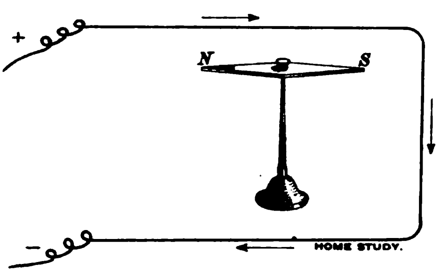

FIG. 2.

is very strong, the needle will turn widely around, approaching a direction at right angles to its original position, whereas, if the current is weak, the needle will turn very little. To exert a greater effect upon the needle, we may arrange the conductor as shown in Fig. 2.

In this arrangement the same conductor is simply carried back *beneath* the needle, and hence both the upper and the lower conductor influence it. The side branch has no effect upon the needle. In accordance with Ampere's swimming rule the *upper* conductor causes the *N* pole of the needle to turn to the left. Now, if we apply the rule to the *lower* conductor, that is, if we imagine ourselves swimming in the lower conductor in the direction of the current, and facing the needle (that is, if we swim on our back), the *N* pole of the needle will turn to our left, which is exactly the same effect the upper conductor has upon the needle; and we thus see that the turning forces exerted by the current upon the needle will be the same for both upper and lower conductors; in other words, the effect of the complete loop of wire, as in Fig. 2, is double the effect of one single conductor.

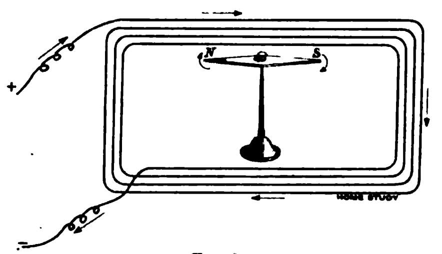

FIG. 3.

Experiment further shows that the effect upon the needle grows with the number of such complete loops, so that the arrangement shown in Fig. 3, which consists of a coil of wire of many complete turns, will powerfully influence the needle.

Since the distance through which the needle of Fig. 3 will turn depends upon the strength of current flowing in the coil, this arrangement forms a very simple indicator of current strength. Thus, suppose the *N* pole of the needle turns 2 inches to the left, when a current of a given strength is flowing in the coil; then we know in all future work, with that instrument, that whenever the *N* pole of the needle turns 2 inches to the left, a current having that once-for-all determined value is flowing in the coil. An instrument of this kind is called a *galvanoscope*. When it is accurately constructed, and supplied with a scale showing how many degrees the needle turns when a given current flows in the coil, the instrument becomes an actual measure, or *meter*, of currents, and is then called a *galvanometer*. The needles of galvanometers

are usually supplied with a spring or similar attachment which brings the needle back to its original, or zero, position whenever the current in the coil dies out. To make these instruments more sensitive in responding to the influence of a current in the coil, they are often fitted with an attachment whereby the effect of the earth's magnetism on the needle is annulled, thus leaving it subject to the influence of the coil alone. This attachment very often consists of a permanent bar magnet, which is placed in the plane of the coil and parallel to it, and which exerts about the same effect on the needle as the earth's magnetism does, but in the opposite direction, the two forces about neutralizing each other.

Calibration for Amperes.—It is possible to *calibrate* a galvanometer, that is, to ascertain, by special measurements or comparison with a standard instrument, the number of amperes corresponding to any particular deflection of the needle or pointer. Thus, suppose it has been positively determined that a deflection of the needle of 180 degrees is produced by a current of 5 amperes flowing in the coil; then a current of 5 amperes will *always* produce that deflection if the instrument remains in the same condition. When, by a series of such comparisons, the various equivalent currents for certain deflections have been ascertained, the galvanometer scale may be divided up into amperes, so that the strength of the current, in amperes, may be read directly from the instrument. Such a galvanometer should be called an *amperemeter*. A device of this kind would, however, be too delicate—too sensitive—for practical work. The commercial ammeter, while embodying principles similar to those just stated, is constructed in a different manner.

Commercial Ammeters. — An instrument specially constructed for practical work, and in extended use in this country, is shown by Fig. 4.

In this instrument, the conductor which carries a current does not act upon a magnetic needle, but upon a metal core built of many strands of iron wire closely bound together, as shown at C. The coil itself, A, into which the current is carried by way of the contact a, and which it leaves by way of the contact b, is in the form of a hollow coil, called a *solenoid*, in which is the core C suspended from the hook h on the cross-arm P. This cross-arm is supported on a knife-edge bearing, and the weight of the core C is balanced by the counterweight W to such an extent that the needle N points to zero on the dial D.

The action of the instrument is as follows: The weight W at one end of the cross-arm P tends to keep the pointer N at zero. When the current comes on and traverses the solenoid, the core is "sucked" down into the solenoid. This causes the pointer to travel across the scale, from left to right, through a distance proportional to the amount of current flowing in the circuit. The plumb-bob p shown at the extreme right, inside the glass case, is used for "leveling" the instrument, that is, for setting it truly vertical. There are many other forms of ammeters, but those built for practical work usually depend for their operation upon the same principles; that is, the pointer is made to move by being attached to metal which is either caused to turn by a coil or is sucked into a solenoid.

FIG. 4.

Calibration of a Galvanometer for Volts.—In exactly the same way as an instrument is calibrated for amperes, it may also be calibrated for volts; but in the latter case the galvanometer is calibrated by ascertaining, by special measurements or comparison with a standard instrument, to what number of volts particular amounts of deflection of the pointer correspond. Thus, suppose that it has once been determined that a pressure

of 50 volts causes the needle to deflect through 100 degrees of the scale, then if the instrument remains in the same condition, an electrical pressure of 50 volts will *always* produce that deflection. When, by a series of such comparisons, the various equivalent currents for certain deflections have been determined, the galvanometer scale may be so graduated that the pressure of the current in volts may be read directly from the instrument. Such a galvanometer might be called a *voltmeter*. There are, however, the same objections to its practical use as there are to the galvanometer which is calibrated to *amperes;* and commercial voltmeters, while depending upon the same or similar principles, are differently constructed.

Commercial Voltmeters.—A voltmeter of the same type as the ammeter in Fig. 4 is shown in Fig. 5. The principal difference between the two instruments, and between all ammeters and voltmeters in general, lies in the fact that ammeters are designed to have as *little* electrical resistance as possible, while voltmeters are equipped with *extra* resistance-coils, so as to greatly increase the resistance of the instrument. The reason for this will be explained shortly. The extra resistance-coils are contained in the back of the instrument behind the board R, Fig. 5, and consist of several sheets of cardboard (or similar material) upon which are closely wound many hundred feet of insulated thin German silver wire. This wire is all connected in *series* with the solenoid A by means of connections not shown, and the two free ends are brought to the binding posts or terminals, a and b. At F is a fuse which is also connected with the instrument in series and which, by melting when the current accidentally becomes too great, opens the circuit and thus saves the instrument from destruction. The course of the current in the instrument is as follows: Entering the + binding post a, it traverses all the German silver resistance at the back of the instrument; then enters the fuse F, and from there flows into the solenoid. Leaving the solenoid A, the current is carried out of the instrument by the — binding post b, thus completing the circuit. It will be noticed that the solenoid A of the voltmeter is different to the ammeter solenoid shown in Fig. 4. In the voltmeter, the solenoid consists of a hollow coil of thin copper wire, having a great many turns. The action of the instrument is the same, however, as that of the ammeter: Current in the solenoid "sucks" the core in and thus causes the needle N to travel across the scale, which is calibrated to volts.

Comparison of Ammeters and Voltmeters.—From the above we see that ammeters and voltmeters are really identical instruments, with the exception that ammeters are of very low resistance, while voltmeters are of high resistance. That this is so, and the reasons for it, the following considerations will make clear:

In Fig. 6, let D be a dynamo supplying the four lamps L with current. Let it be

Fig. 5.

known that the resistance of the entire circuit (that is, of the lamps and line-conductors $+C$ and $-C$) is equal to 30 ohms. Let the current in the circuit be equal to 4 amperes, and the pressure of the entire circuit be 120 volts. Then, in order that these values may be indicated correctly, the measuring instruments above described must be used as follows:

I. *Current Measurement.* — The current supplying the lamps L must, after leaving the dynamo, pass to the lamps by way of

the conductor + C, and it must return to the dynamo by the conductor — C. Furthermore, to measure this current with the ammeter of Fig. 4, we know that the entire current must be made to pass through the solenoid A, which will then exert a certain pull on the core C, thus causing the needle to indicate on the dial the value 120 amperes. To allow all this current to pass through the ammeter, the instrument must be connected in *series* with the circuit. This is done by cutting open the circuit at a point usually near the dynamo, and inserting the ammeter in the gap thus formed. The connections having been made, every

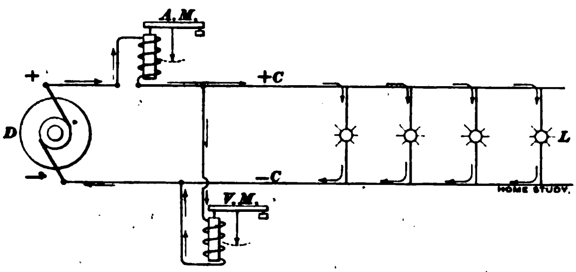

Fig. 6.

variation of current strength in the circuit is indicated upon the dial of the instrument by the varying pull of the solenoid on the core. In Fig. 6, the ammeter, correctly connected, is shown, marked $A.M.$ The rule for this correct connection is, therefore, as follows:

Connect the ammeter in such a manner that the entire current of the circuit is made to pass through the instrument.

II. *Pressure Measurements.*—The maximum pressure in any electrical circuit is equal to the sum of all the pressures which are in series with each other. Thus, in Fig. 6 the maximum pressure is equal to the pressure from the positive dynamo-terminal to the lamps, plus the pressure from the positive side of the lamps to the negative side, plus the pressure from the negative side of the lamps to the negative dynamo-terminal; or, in other words, it is equal to the pressure measured across the dynamo-terminals from + to —.

Now, in every electrical circuit, and in every conductor, the pressure is given by formula (1) namely, $E = C \times R$.

If, therefore, we have an instrument, in which R, the resistance, is absolutely constant (that is, never changes in value), then, if this instrument is connected to an electrical circuit, the current C in it will *always* be the same for a given pressure E; and if this pressure should rise around the instrument, the current in the instrument would rise in exactly the same proportion.

Therefore, if we know just what current in the instrument is produced by a certain pressure, we have a measure of this pressure; in other words, a voltmeter. This being the case, the pressure is measured with a voltmeter by connecting the terminals of the instrument around that portion of the circuit for which the pressure is to be determined. Thus, in Fig. 6, where we are desirous of measuring the total pressure, the instruments must be connected *across* the circuit, as shown by $V. M.$ We therefore have the following rule for the correct connection of the voltmeter in any electrical circuit:

Connect the voltmeter in such a manner that its terminals are around that portion of the circuit in which the pressure is to be determined.

Never connect the voltmeter in series, because in that case it acts like an ammeter, and, not having the current-carrying capacity of an ammeter, it will be burned out by the excessive current passed through it.

Conclusions.—From the above we see that since a voltmeter may be required to measure high pressures, as, for instance, in Fig. 6, the amount of current which could thereby be forced through the instrument would be enormous. To prevent this great quantity of current from traversing the voltmeter, a very large resistance is placed in series with it, as explained in connection with Fig. 5. The ammeter, on the other hand, which depends upon the entire current for its action, and which is subjected to a comparatively low pressure only, is designed with its resistance as low as possible, so that no pressure may be wasted in sending the current through it. Thus it is now evident that *the less the resistance of the ammeter and the greater the resistance of the voltmeter, the better, as a rule, are the instruments.*

INCRUSTATION IN STEAM-BOILERS.

W. H. Booth.

Chemical and Mechanical Means of Preventing Boiler-Scale—Three Classes of Injurious Feed-Water—Chemical Composition of Boiler-Scale.

PERHAPS there is no subject which has called forth so much useless discussion or so many worthless nostrums as that of boiler incrustation. The great mistake made by vendors of patent nostrums for preventing or curing scale in steam-boilers is that, having found a certain compound suitable for a certain boiler, they are apt to conclude that the compound is of general utility, and they advocate it *in* season and *out*, utterly disregarding the fact that the conditions vary so much that it is difficult to find even *two* boilers under exactly the same conditions as to feed-water and its necessary treatment; for though the feed may be identical, it is possible that one boiler may have so much more work to do than the other that the compound which suits the lightly-worked boiler will cause foaming in the other, and, consequently, have to be abandoned.

It is therefore desirable that water be analyzed and its constituent impurities ascertained, so that a proper treatment may be accorded it. The means adopted for preventing bad effects from incrustation are either *chemical* or *mechanical*, or both. Chemical means consist of the use of substances which precipitate the solid impurities of the water and allow them to settle in some quiet part of the boiler, whence they can conveniently be blown out.

Mechanical means often depend upon the introduction in the boilers of greasy, starchy, or gelatinous substances, with the intention that as each particle of solid matter is freed from the water it shall become coated with some of the composition and thus prevented from adhering to other particles or to the boiler-plates. Large quantities of mud are formed in this way, which require, for removal, the regular use of the blow-out tap. This is a direct loss in proportion to the amount of hot water wasted by the blow-out, and is opposed to the attainment of economy in fuel combustion. It is not out of place here to inquire into the chemistry of boiler-scale. The guide taken in this article is the treatise on the question by the late Dr. Angus Smith, who made a very careful examination of the whole subject.

He divided waters that are injurious to boilers into three main classes:

1. Alkaline, or chalk, water.
2. Neutral, or gypsum, water.
3. Acid water.

Numbers 1 and 2 are very frequently found together.

Numbers 2 and 3, also, are often found together.

Numbers 1 and 3 cannot be found together, as they would tend to neutralize each other until only one was left.

Now, all such waters are injurious if put into a boiler, the first two because they form scale, and the third because it dissolves the plates.

Chemists tell us that carbonate of lime, which is the solid constituent of water No. 1, is soluble in water only when that water also contains carbonic acid gas in solution; on boiling the water, the gas is driven off and the carbonate of lime is no longer soluble.

Baron Bunsen determined the solubility of carbonic acid gas in water as 1.7967 volumes at 32°, and only .9014 volumes at 68°, and, whatever the pressure, the dissolved volume of gas remains constant. Hence, the *weight* of gas absorbed is proportional to the pressure. The amount dissolved decreases with rise in temperature, until at boiling-point none is left.

Of the usual impurities in feed-waters, 100 parts of cold water dissolve .0036 of carbonate of lime and as much as .23 of lime sulphate, or gypsum.

At boiling-heat no carbonate remains, but there is still left .21 of the sulphate.

Carbonate of magnesia to the extent of .02 is dissolved cold. This disappears in boiling.

Sulphate of soda is soluble to the extent of 5.02 of the anhydrous salt at 32°, and as much as 50.65 parts at 90°, though 42.65 parts only are soluble at or near boiling-

point, showing a decrease beyond a certain temperature.

Sulphate of magnesia, from having a solubility of 24.7 at 32°, attains, at 222°, as high a solubility as 132.5.

As in the case of carbonate of lime, the presence of carbonic acid is necessary to keep in solution the carbonate of magnesia, a similar salt. As water can be freed from carbonates by boiling, carbonate waters are termed "temporarily" hard, to distinguish them from "permanently" hard, or sulphate, waters.

A carbonate water quickly forms scale, because the whole of its dissolved lime precipitates at once when boiling-temperature is reached, but from this it must not be inferred that sulphate waters do not form scale. They do make a scale, and of a worse nature than a carbonate scale, as will now be shown: After some hours the water in a boiler has changed entirely several times and what is then in the boiler is saturated with all the sulphate left behind. It can then dissolve no further quantity, and scale is formed from that time. Further, when the circulation in a boiler is not rapid and the steam-raising surfaces are near the water-surface, steam is actually formed upon the plates, and, as a molecule of water goes off as steam, it leaves the minutest particle of sulphate right upon the plate ready for instant adhesion, and the scale so formed is very tough and tenacious, more so than a carbonate scale.

The great variety observed in the hardness of scale depends upon the admixture of other substances in the water.

A little clay would probably soften a scale by the particles of clay becoming intermixed with those of the lime salt, and the strength of the scale would be decreased.

Carbonate of lime has the chemical symbol CaO, CO_2 which shows that it is a compound of lime and carbonic acid. As it exists in water it may be written $CaO, CO_2 + CO_2$, the quantity after the sign of addition being the gas which keeps it in solution. If, therefore, to water containing lime carbonate in solution we add plain lime, CaO, which is the oxide of the metal calcium, we cause a peculiar action to take place. The lime absorbs the free gas and the following equation shows what occurs:

$(CaO, CO_2 + CO_2) + CaO = 2(CaO, CO_2)$.

We have simply absorbed the gas and made more carbonate, which, with the old carbonate already present, will all precipitate. If this process is carried on inside a boiler, the quantity of mud formed will be large, and after all is done in the way of blowing out, we can never prevent some scale from forming.

In boilers of the Lancashire type it is usual for much mud to deposit and harden at the back end of the boiler-bottom; we have seen it there from 6 to 8 inches thick.

If time and space allow, the operation can be conducted outside the boiler and the water cleared by slow settlement and filtration, in which case no scale will be formed in the boiler. In the March number a form of apparatus for this purpose will be illustrated. Another plan has been suggested: the addition of sal ammoniac. Sal ammoniac has the formula NH_4Cl, and the reaction with the lime carbonate is as follows: $CaO, CO_2 + 2(NH_4Cl) = CaCl_2 + (NH_4)_2CO_3$, highly soluble calcium chloride and volatile carbonate of ammonium being formed. The lime chloride can be blown out and the ammonium carbonate goes off with the steam. The danger of this is stated to be a tendency to the formation of hydrochloric acid if the salt is added in excess, the decomposition of NH_4Cl giving ammonia, NH_3, and hydrochloric acid, HCl. The former injures brass or copper and the latter injures the boiler-plates, so that if this method be tried it would be advisable on the last count to make frequent tests of the water drawn from the boiler with litmus paper, which for the water to be safe must be blued by it. If reddened, to correct the evident acidity, we add soda, Na_2O, when the action which occurs is $Na_2O + 2HCl = 2NaCl + H_2O$, or simply common salt and water, which would in time accumulate and require blowing out. In the face of the risk, this method is not to be specially recommended.

The most common present-day practice is the use of soda, NaO_2, either in its anhydrous form or as its caustic hydrate $NaOH$. The effect of this when put into a carbonate water is as follows: $CaO, CO_2 + CO_2 + Na_2O = CaO, CO_2 + Na_2CO_3$.

The lime falls on the subtraction of the free gas, and carbonate of soda is formed; the latter being very soluble, may be neglected for a long time. This process still leaves the sediment in the boiler to be blown out, and is necessarily accompanied by a waste of hot water.

Turning now to sulphate waters, we have for lime sulphate the chemical formula $CaSO_4$, and it is found that if to water containing gypsum we add carbonate of

soda, or Na_2CO_3, the following reaction takes place: $CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$.

Of these the first is our old friend, carbonate of lime, which precipitates, and the next is sulphate of soda, which is very soluble and harmless, and may be long neglected.

We notice here, then, a curious fact. When we use plain soda for dealing with lime carbonate, we get as one product carbonate of soda, which is just what is needed for dealing with the lime sulphate. This was first pointed out by Dr. Smith, who argued correctly that in water which contains both carbonate and sulphate there is a double decomposition effected, the soda added doing duty first upon the carbonate, and then, when itself turned to carbonate, proceeding to act on the sulphate, thus turning all the dissolved lime salts to mud and itself becoming sodium sulphate. Of course it is necessary to know, in making use of this double reaction, what the ratio is of carbonate to sulphate in a mixed water. It is not necessary to go deeper into the ratio of the combining weights of lime and soda salts, it being sufficient for our present purpose to know that 100 parts by weight of lime carbonate will call for 80 parts of caustic soda, $2(NaHO)$, to neutralize its suspension and precipitate it, or 62 parts of the anhydrous oxide Na_2O.

Again, 100 parts of lime sulphate call for 78 parts of carbonate of soda to precipitate the sulphate as carbonate. Now, 78 parts of carbonate of soda is equal to 45.6 parts of anhydrous caustic soda and to 59 parts of true caustic, $2(NaHO)$.

The ratio of the caustic soda equivalents in the two cases of lime carbonate and sulphate is 1.36 : 1.00 or 1 : 0.734, that is to say, practically, as 8 to 6. In other words, if a water contains 6 grains of carbonate of lime, the precipitation of this by caustic soda will produce as much carbonate of soda as will then convert 8 grains of lime sulphate into carbonate.

The rules to be followed for different ratios are:

1. Carbonate waters: For each 100 grains of the carbonate of lime add 80 grains of caustic soda.

2. Sulphate waters: For each 100 grains of sulphate of lime add 78 grains of carbonate of soda.

3. Mixture of both lime carbonate and sulphate: For the carbonate add 80 grains of caustic soda per 100 grains, as in rule 1. For the sulphate, subtract from the amount of sulphate per 1,000 gallons, 1.36 times the weight of lime carbonate. If there is any remainder, add 78 grains of carbonate of soda for each 100 grains, as in rule 2. Thus, if the sulphate does not exceed in quantity 8 grains for every 6 grains of carbonate, it may be neglected, for the caustic soda will be sufficient for this when it has done its part on the lime carbonate. In speaking of caustic soda we refer to the substance known as sodium hydroxide ($NaHO$), not to the dry powder formed by oxidizing sodium, which is rarely seen commercially.

The commercial caustic is originally made from carbonate by boiling with quicklime, settling, and evaporating the clear solution, and must not be confounded with soda ash, which is, or ought to be, carbonate of soda. Commercial soda ash often contains as much as 50% of impurities, such as the sulphate, sulphite, and chloride of soda.

Before considering how to prevent scale, it is perhaps as well to state that no amount of treatment with soda will remove deposited lime from the inside of a boiler. What soda can do is to facilitate the separating of carbonate of lime and to change sulphate into carbonate.

Before going further, the third class of water calls for notice, namely, acid water. This is not found to accompany carbonate water, but may accompany water containing sulphates. The reason for this is simple. If acid water is mixed with chalk, or carbonate, water, the acid acts upon the carbonate and converts it into sulphate or chloride, until either the acid is neutralized or the carbonate is wholly converted.

The causes of acidity in feed-water are various and sometimes unexpected.

In one case met with by the writer, the explosion of a steam-boiler could be traced to the unexpected acidity of feed-water. The owners of the boiler—new owners—were men who were working several other boilers with the same stream of water and used little or no soda. They treated their newly acquired boiler in the same manner, and it exploded in a few months from rapid internal corrosion. Investigation by the writer and others revealed the fact that the exploded boiler drew water from a water-wheel by-wash, while the uninjured boilers drew from the same stream 200 yards lower down where the by-wash and main body of the stream had become mixed by passing over a fall. Further search revealed a drain discharging "spent acid" from an electro-plating works into the by-wash at the same side as the feed-pipe inlet of the exploded

boiler. This was sufficient to account for the explosion. Below the fall the acid was diluted in the main stream; above, it was stealthily creeping along the bank. There are natural acid waters also. In them the acidity sometimes arises from sulphate of iron, sometimes from vegetable matter. There is one cure for acid water, and it is an easy one; the acidity must be neutralized by adding alkali in sufficient quantity.

This alkali may be lime or it may be soda, and in some waters as much as half a pound of soda carbonate is required for each 1,000 gallons of water; for some large boilers this means a daily addition of from 2 to 4 pounds of soda carbonate. Lime would neutralize double the quantity, but would then go into the boiler and form scale.

It seems reasonable to suppose that when an acid water must be used it would be well to pass it through a filter of limestone chips. These would neutralize the acidity and possibly only become changed by the water and not dissolved and carried away with it. In any case, to prevent rapid corrosion by the water it must be served with sufficient alkali to cause it to produce the blue reaction on litmus paper.

As regards the final removal of scale or mud, there are two opinions. One is that the removal of sediment after treatment should take place *outside* the boiler; the other, that the sediment should be removed from the *inside* of the boiler.

In the March number various methods will be explained and illustrated.

PAVEMENTS.

Benjamin F. La Rue.

WHAT CONSTITUTES A SATISFACTORY PAVEMENT—THE WEARING-SURFACE, BASE, AND NATURAL FOUNDATION—QUALITIES ESSENTIAL TO AND MATERIALS SUITABLE FOR EACH.

WITH reference to the purposes for which they are used, pavements may be considered to be of two general classes, namely, roadway pavements and footway pavements. It is desirable that the pavement for a roadway should possess a smooth, even, and reasonably hard surface, affording easy and comfortable transit for vehicles at any ordinary speed, and that footway pavements should be of such a character as to be easy and pleasant to walk upon. We all recognize a satisfactory roadway pavement when we ride over it, and a suitable footway pavement when we walk upon it, but we are not generally familiar with the conditions essential to a properly constructed and satisfactory pavement of either kind. Indeed, comparatively few of us understand of what a pavement really consists, further than that we are able to name the material in the surface of those pavements with which we are familiar. In the present article we will endeavor to learn something about the essential parts of, and the conditions requisite to, a suitable roadway pavement.

Pavements are for the purpose of improving the facilities for, and reducing the expense of, the transportation of merchandise and all industrial products, and for increasing the safety, speed, comfort, and pleasure of travel. Such are the purposes for which they are constructed, and for any particular case, the pavement that will meet these conditions most effectually and with the greatest degree of economy, will be the best and most suitable. It should afford a smooth, even surface, offering the least possible resistance to traction and over which vehicles may pass with ease, safety, and comfort, and should, at the same time, furnish an impervious covering that will protect the soil of the natural foundation; it should also have strength to distribute the weight of the loads concentrated upon the wheels over sufficient areas of the natural foundation to be supported without destructive effect upon that foundation. This is necessary in order that the pavement may retain its smooth and even surface.

In the construction of a pavement we have to deal with three different, and more or less distinct, features, namely, the *wearing-surface*; the *base*, or *artificial foundation*; and the *natural subsoil foundation*, or *roadbed*. The first two are integral parts of the artificially constructed pavement, while the last generally consists of the bed of natural earth, or subsoil, upon which the pavement

rests, although, where the natural soil is very unstable, this foundation, also, is sometimes artificially prepared.

The wearing-surface is the upper layer of material which constitutes the finished surface of the roadway and which sustains the traffic; it is that visible portion of the pavement with which we are familiar, and by which the traffic is directly affected. In order that this wearing-surface may be satisfactory for public travel, there are certain qualities which it should possess.

It should be *impervious* to water or other liquids that may fall upon or flow over its surface, and its surface should be of such form as to promptly discharge them into the side gutters and drainage outlets.

It should be *hard*, *tough* and *durable*, so as to resist the wear of the traffic and the disintegrating effect of the elements.

It should be *smooth* and *even*, so as to offer the minimum resistance to traffic, and, at the same time, should be of such a character as to afford a secure foothold for horses, and one which will not become polished and slippery from use.

It should be comparatively *noiseless*, of such a character as to yield very little dust or mud, and should be *easily cleaned*.

It should be adapted to the grades and suited to the traffic.

There are a number of different kinds of material that fill the above requirements more or less perfectly, and that have proved reasonably satisfactory. Others have also been tried, but have not proved suitable. The following materials have been quite extensively used, namely: *asphalt*, *bricks*, *stone blocks*, *wood blocks*, *cobblestones*, and *broken stone*. These materials are named in about the order of their comparative merits, although the true value of any one of them depends largely upon the character of the traffic to which it is subjected. For instance, if the pavement is subjected to a constant and exceedingly heavy traffic, granite blocks will be the best material for the wearing-surface; for a residence street, having a moderate traffic of reasonably light character, with more or less pleasure-driving, asphalt may be the best. Most of the materials named above have proved reasonably satisfactory for the wearing-surfaces of properly constructed pavements where the traffic is of the character to which the material is adapted.

As the surface is the only part of a completed pavement that is visible, we very naturally designate the pavement by the name of the material constituting its wearing-surface, and we are very apt also to consider the wearing-surface to be in all respects representative of the entire pavement. We not uncommonly attribute the condition of a pavement, and whatever of merit it may possess, wholly to the wearing-surface; if the pavement has proved satisfactory, we generally think that another pavement, having a wearing-surface composed of the same material, would be equally satisfactory; and if the pavement has not proved satisfactory, we are inclined to condemn all pavements having wearing-surfaces of the same material.

This idea, though quite common, is very erroneous. The wearing-surface is a very essential part of any pavement, and none can be satisfactory unless this portion of it is formed of suitable material and is properly constructed. Though it be ever so well constructed, however, the wearing-surface cannot satisfactorily sustain the traffic without being in turn supported by a firm and unyielding foundation, any more than the superstructure of a building can support its contents and retain its proper form unless it is upheld by a suitable foundation, or than a vehicle that is mounted on broken wheels can be a satisfactory means of transportation.

As a matter of fact, the wearing-surface of a pavement is properly little *more* than a surface, and, of itself alone, is not capable of sustaining traffic and distributing weight over a sufficient portion of the yielding soil beneath it. It is, therefore, necessary that the wearing-surface of any pavement should rest upon, and be sustained by, a foundation having sufficient strength to resist deformation from the concentrated loads of the traffic, and it should also distribute the loads over sufficient areas of the underlying soil so that the soil will not be unevenly compressed or distorted, but will sustain the loads without injury. In any pavement, the value and condition of the wearing-surface, and, consequently, of the pavement as a whole, will depend largely upon the efficiency of the foundation. It is thus seen that a well-constructed foundation of suitable material is very essential.

The materials commonly used for the foundations are *hydraulic cement concrete*, *bituminous concrete*, *broken stone*, *bricks*, *gravel*, *sand*, and *plank*. Here, again, the materials are named in the order of their respective merits. Hydraulic cement concrete, composed of hydraulic cement, sand, and broken

stone, forms, when it has become thoroughly set, a solid, unyielding foundation that is also impervious to water; it very efficiently distributes the loads upon, and protects, the underlying soil of the natural foundation; the same is, to a less extent, true of bituminous concrete, which is commonly composed of coal-tar residuum, creosote-oil and broken stone. Bricks, broken stone, gravel and sand all form, under suitable conditions, reasonably solid, but not impervious foundations, while foundations formed of planks are neither unyielding nor impervious. Plank foundations, as usually constructed, are not capable of distributing the loads concentrated upon the wheels over sufficient areas of the underlying soil to prevent the latter from being unevenly compressed; depressions are formed in the subsoil by the passage of heavy loads, which not only allow the planks to spring with the passage of all subsequent loads, thus disturbing and destroying the form of the wearing-surface, but also retain water and tend to further destroy the natural foundation. Plank foundations form at best but temporary expedients; under the usual conditions they soon decay and become even worse than useless.

In the accompanying illustration is shown the cross-section of a brick pavement. The wearing-surface *b* is composed of bricks set on edge upon the layer of concrete *c*, which is spread upon the natural earth foundation *e*. The curbing *k* consists of thin slabs of stone set along the edges of the roadway to define its boundary and serve somewhat as a retaining wall for the adjacent earth. The flagstone *f* of the sidewalk rests directly upon the layer of sand *s*, which is spread upon the natural earth foundation *e*, and acts somewhat as a cushion to distribute and equalize the pressure.

THEORY AND PRACTICE.

THEORETICAL AND PRACTICAL FORMULAS—RULES OF THUMB NOT PRACTICAL FORMULAS—THEORY AS A TEST, SAFEGUARD, AND GUIDE—RIVETED JOINTS AS AN EXAMPLE.

THE controversy between theory and practice in the machine-shop, or between the drafting-room and the shop, or the college-graduate engineer and the practical machinist, is as old as the art of machine-building. There is no doubt that machines were built long before theory gave us the reasons for the results obtained, and long before the age of formulas. Among the artisans of old, rules always existed, deviating from which would have been dangerous in many ways, and those rules were, in the majority of cases, so well established by the results obtained that their correctness could not and cannot to-day be questioned; they have stood the test of theoretical investigation since. But there have been other rules, long cherished ones, many of which are still lingering in the minds of some people, rules that theory has no explanation for. These are the "rules of thumb." While a purely theoretical solution of even the simplest problem in the mechanical arts must necessarily be incomplete on account of the utter impossibility of theoretically considering each and every secondary influence bearing on the final result, theory is the only test, safeguard, and guide for our practical rules. The "theoretical formula" forms as it were the skeleton upon which practical experience builds the flesh which must be added to complete the body, and the result is the "practical formula," which takes account of all minor details and allows for all those secondary influences which theory had overlooked, either purposely, to avoid too complicated a formula, or without purpose, in cases where the true cause of a certain effect had not been recognized. The more thoroughly theory investigates causes and subsequent effects, the more closely do its formulas tally with those obtained by practical methods, until finally the ideal "theoretical" formula becomes at the same time the ideal "practical" one. Of these there are at present very few. It is hoped, however, that there will come a time when eternal peace will reign between theory and practice, and when there will be no more mysterious rules of thumb that cannot be made transparent even to the strongest X-rays that science can produce.

In order to illustrate the above, there are given below a number of practical formulas and tables relating to riveted lap-joints—a subject that is generally among the first to be treated in text-books on machine design; and a few remarks pointing towards the theories involved are added. The tables are considered as embodying the best practice and are valuable, therefore, to the practical machinist in laying out such work.

In every case the thickness t of the shell is given, and upon this the other data are dependent. Commencing with the dimensions e, Fig. 1 (the distance of the center line of rivets from the edge of each plate) these must be such as to ensure safety against the breaking of the plate as indicated at A. A simple theoretical formula for calculating the values of e cannot well be given, as the strains and stresses at these points are complicated on account of calking. It is an ordinary practical rule to make e equal to $1\frac{1}{2}$ times the diameter d of the rivet; for thin plates this may be somewhat increased, say to $1\frac{5}{8}$ times the diameter of the rivet. Too wide laps make it difficult to calk the joints, but, nevertheless, some advise as wide a lap as 3 to $3\frac{1}{2}$ times the diameter. The diameters of the rivets should be such as to be secure against crushing as well as shearing. The diameters d given in Table I are safe against crushing, and if the proper pitch, or distance between rivets, is chosen, they will also be safe against shearing. The diameter of rivet can be found by theoretical deduction, taking into account the fact that there is a limit to the size of hole which it is possible to punch; or, in other words,

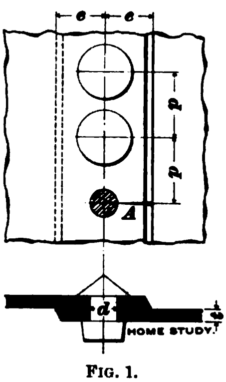

FIG. 1.

that, if the diameter of the punch is smaller than a certain limit, the punch will be crushed. As, however, much diversity of opinion exists as to the "standing quality" of a punch, it will be evident that a theoretical formula thus evolved would not be satisfactory. A practical rule however is the following: $d = \frac{7}{8}t + \frac{3}{8}''$. By this formula the values in Table I have been calculated.

TABLE I.

t	d
Inch.	Inch.
$\frac{3}{16}$	$\frac{1}{2}$
$\frac{1}{4}$	$\frac{9}{16}$
$\frac{5}{16}$	$\frac{11}{16}$
$\frac{3}{8}$	$\frac{3}{4}$
$\frac{7}{16}$	$\frac{13}{16}$
$\frac{1}{2}$	$\frac{13}{16}$
$\frac{9}{16}$	$\frac{7}{8}$
$\frac{5}{8}$	$\frac{15}{16}$
$\frac{11}{16}$	1
$\frac{3}{4}$	$1\frac{1}{16}$
$\frac{13}{16}$	$1\frac{1}{16}$
$\frac{7}{8}$	$1\frac{1}{8}$

FIG. 2.

To prevent the bursting of the shell along the center line of the rivets, the distance between the latter—or the pitch p—must be large enough. Theory says as follows: Take a strip A of the width p. (See Fig. 2.) The ends of this strip are held together at the joint by one rivet. Suppose sufficient force is applied to tear the joint apart, then, either the rivet will be shorn off or the plate will burst along the center line $B\,C$. To give equal chance to both elements, the shearing strength of the rivet must be equal to the tensile strength of the metal of the plate on both sides of the rivet-holes $(p - d)$. Now it is very easy to make up the following equations:

$$a \times S_s = A \times S_t.$$

in which a = cross-sectional area of rivet;
A = cross-sectional area of plate between two rivet-holes = $(p - d) \times t$;
S_s = shearing strength of material of rivet per square inch;
S_t = tensile strength of material of plate per square inch.

$$a \times S_s = (p - d) \times t \times S_t.$$

$$\frac{a \times S_s}{t \times S_t} + d = p.$$

If the tensile strength of the material of the plate is known, either from its being stamped on the plate, as is often done, or by actual testing, and if the shearing strength of the rivet material is also known, the above formula seems at once serviceable. But it is a purely theoretical formula and, as is to be expected, does not allow for various minor influences which are at work on the final result. As will be seen from Fig. 2, it is necessary, first, to make allowance for the fact that the plate at a lap-joint is subjected, not to a straight pull, but to an oblique one and has therefore to resist a force which tends to bend it. We cannot therefore insert the full tensile strength in our formula, but must use a smaller amount. Thus, if a material has by test a tensile strength of 45,000 pounds, it will be well to substitute 40,000 in the formula. Punching the holes will also have some effect on the strength of the plate, the material being crowded up around the edge of the hole. Annealing rectifies that however to a great extent. Fig. 2 also shows that the rivet is not subjected to a shearing stress pure and simple, but to tension as well. It will be advisable, therefore, to modify the constant for S_t also. It must further be remembered that it makes a great difference whether the rivet-holes are punched or drilled. 46,000 pounds per square inch is a good value for iron rivets in punched holes. With these values, then, our formula now reads

$$\frac{a \times 46{,}000}{t \times 40{,}000} + d = p.$$

Table II has been originally calculated from this formula, but the figures for p have been still more "rounded off," so as to increase more uniformly with the thickness of the plates.

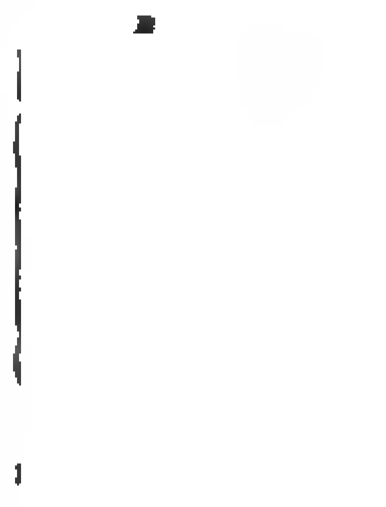

FIG. 3.

The original formula having been so much modified, it is not considered by many anything out of the way to go one step further for simplicity's sake and to assume $S_s = S_t$, which makes the formula look like this:

$$\frac{a}{t} + d = p.$$

From this, Table III has been calculated. The assumption that $S_s = S_t$ is not necessarily arbitrary, however, as, in cases where the holes are drilled in iron plates, this condition approximately exists. The figures in Table III are also better suited for steel plates and iron rivets.

TABLE II.

Single-riveted lap-joints for wrought-iron plates, holes punched, not annealed.

t	d	p
Inch.	Inch.	Inch.
$\frac{3}{16}$	$\frac{1}{2}$	$1\frac{1}{2}$
$\frac{1}{4}$	$\frac{9}{16}$	$1\frac{3}{4}$
$\frac{5}{16}$	$\frac{11}{16}$	2
$\frac{3}{8}$	$\frac{3}{4}$	$2\frac{1}{8}$
$\frac{7}{16}$	$\frac{13}{16}$	$2\frac{1}{4}$
$\frac{1}{2}$	$\frac{13}{16}$	$2\frac{3}{8}$
$\frac{9}{16}$	$\frac{7}{8}$	$2\frac{1}{2}$
$\frac{5}{8}$	$\frac{15}{16}$	$2\frac{5}{8}$
$\frac{11}{16}$	1	$2\frac{3}{4}$
$\frac{3}{4}$	$1\frac{1}{16}$	$2\frac{7}{8}$
$\frac{13}{16}$	$1\frac{1}{16}$	3
$\frac{7}{8}$	$1\frac{1}{8}$	3

TABLE III.

Single-riveted lap-joints for wrought-iron plates, holes drilled, or steel plates with iron rivets.

t	d	p
Inch.	Inch.	Inch.
$\frac{3}{16}$	$\frac{1}{2}$	$1\frac{1}{2}$
$\frac{1}{4}$	$\frac{9}{16}$	$1\frac{5}{8}$
$\frac{5}{16}$	$\frac{11}{16}$	$1\frac{3}{4}$
$\frac{3}{8}$	$\frac{3}{4}$	$1\frac{7}{8}$
$\frac{7}{16}$	$\frac{13}{16}$	2
$\frac{1}{2}$	$\frac{13}{16}$	$2\frac{1}{8}$
$\frac{9}{16}$	$\frac{7}{8}$	$2\frac{1}{4}$
$\frac{5}{8}$	$\frac{15}{16}$	$2\frac{3}{8}$
$\frac{11}{16}$	1	$2\frac{1}{2}$
$\frac{3}{4}$	$1\frac{1}{16}$	$2\frac{5}{8}$
$\frac{13}{16}$	$1\frac{1}{16}$	$2\frac{5}{8}$
$\frac{7}{8}$	$1\frac{1}{8}$	$2\frac{3}{4}$

TABLE IV.

Double-riveted lap-joints for wrought-iron plates, punched holes, not annealed.

t	d	p	c
Inch.	Inch.	Inch.	Inch.
$\frac{3}{16}$	$\frac{1}{2}$	2	$1\frac{3}{4}$
$\frac{1}{4}$	$\frac{9}{16}$	$2\frac{1}{8}$	$1\frac{7}{8}$
$\frac{5}{16}$	$\frac{11}{16}$	$2\frac{1}{4}$	2
$\frac{3}{8}$	$\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{3}{16}$
$\frac{7}{16}$	$\frac{13}{16}$	$2\frac{3}{4}$	$2\frac{3}{8}$
$\frac{1}{2}$	$\frac{13}{16}$	3	$2\frac{9}{16}$
$\frac{9}{16}$	$\frac{7}{8}$	$3\frac{1}{4}$	$2\frac{13}{16}$
$\frac{5}{8}$	$\frac{15}{16}$	$3\frac{1}{2}$	3
$\frac{11}{16}$	1	$3\frac{5}{8}$	$3\frac{1}{8}$
$\frac{3}{4}$	$1\frac{1}{16}$	$3\frac{3}{4}$	$3\frac{1}{4}$
$\frac{13}{16}$	$1\frac{1}{16}$	$3\frac{7}{8}$	$3\frac{3}{8}$
$\frac{7}{8}$	$1\frac{1}{8}$	4	$3\frac{1}{2}$

For double-riveted lap-joints our last formulas evidently take the following forms:

$$\frac{2a+46{,}000}{t+40{,}000}+d=p\,;\quad \frac{2a}{t}+d=p,$$

as can easily be seen from Fig. 3, following the same reasoning as before in dealing with the single joint. Tables IV and V give good practical values for p.

It remains to say something about the values of c, the distance between center lines of rivets. These have been chosen simply so that each rivet lies outside of two circles drawn around the two adjoining rivets with a radius equal to $\frac{p}{2}$ as shown in Fig. 4.

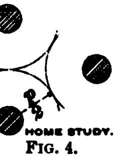

FIG. 4.

TABLE V.

Double-riveted lap-joints, for wrought-iron plates, drilled holes or steel plates with iron rivets.

t	d	p	c
Inch.	Inch.	Inch.	Inch.
$\frac{3}{16}$	$\frac{1}{2}$	2	$1\frac{3}{4}$
$\frac{1}{4}$	$\frac{9}{16}$	$2\frac{1}{8}$	$1\frac{7}{8}$
$\frac{5}{16}$	$\frac{11}{16}$	$2\frac{1}{4}$	2
$\frac{3}{8}$	$\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{3}{16}$
$\frac{7}{16}$	$\frac{13}{16}$	$2\frac{5}{8}$	$2\frac{3}{16}$
$\frac{1}{2}$	$\frac{13}{16}$	$2\frac{3}{4}$	$2\frac{3}{8}$
$\frac{9}{16}$	$\frac{7}{8}$	$2\frac{7}{8}$	$2\frac{1}{2}$
$\frac{5}{8}$	$\frac{15}{16}$	3	$2\frac{9}{16}$
$\frac{11}{16}$	1	$3\frac{1}{8}$	$2\frac{3}{4}$
$\frac{3}{4}$	$1\frac{1}{16}$	$3\frac{1}{4}$	$2\frac{13}{16}$
$\frac{13}{16}$	$1\frac{1}{16}$	$3\frac{3}{8}$	$2\frac{15}{16}$
$\frac{7}{8}$	$1\frac{1}{8}$	$3\frac{1}{2}$	3

The foregoing illustration shows how much practical rules deviate from the results of theoretical calculations; it shows also, however, that the latter are the true starting-points—the foundations to build on with practical experiments. The same principle should be followed throughout the whole field of machine-designing. There are even many cases where a calculation beforehand is out of the question, where one must almost lay out the whole machine by intuition and then go over it with the magnifying-glass of theory, and add where we find too little and take off where we find too much.

WATER-GAS.

George F. Lord

Its Manufacture—How it is Purified—Wet and Dry Meters—Analysis of the Gas-Flame—Principle of the Bunsen Burner.

ANCIENT philosophers regarded fire and water as two elements which were in direct opposition to each other. But modern science has demonstrated that water can be decomposed into two gases, one of which will burn; and again, that water is one of the products of combustion. For experimental purposes, the decomposition of water into hydrogen and oxygen is effected by *electrolysis*—a method fully described in Home Study Magazine for December, 1896. We will now describe the commercial process employed in the manufacture of hydrogen- or water-gas—explaining how it is made to furnish light and heat for public use.

The first operation is carried on in the "generator." This is practically a large receptacle or fire-pot, so constructed that it can be hermetically sealed at the bottom, in order to prevent the entrance of air. It is filled with a mass of anthracite coal—technically called a "charge." This is fired and brought to a state of incandescence through the aid of a blast of air from a blower. This is the only draft that the fire receives, since the generator is sealed. The heated gases—the product of this vigorous combustion—pass upwards through the "superheater" or "regenerator." Here they meet with a surface of hot brickwork, arranged in a checkered fashion in order to expose the ascending gases to a large heating area. The air-blast is continued until, on looking through the peephole at the side of the regenerator, these bricks are seen to be very highly heated. The air-valve is then closed and a jet of steam is forced upward through the glowing coal. The heated carbon, searching for oxygen, cannot find it in a free state now that the air-blast is shut off, so it takes it from the steam, uniting with it to form carbon dioxide (CO_2) and liberating the hydrogen. But in passing through the remainder of the glowing coal, the greater part of the CO_2 loses one more atom of oxygen and becomes carbon monoxide (CO). This is the gas which burns with a pale blue flame on the top of a freshly-coaled fire. It is the result of carbon burning in an insufficient supply of oxygen.

The gases, then, which pass upwards into the regenerator are hydrogen, carbon monoxide and carbon dioxide; and, in addition to these, there are sulphur gases formed from the impurities in the coal. As all these gases enter the lower end of the regenerator, they meet with a spray of petroleum, which is forced in by a small jet of steam. The purpose of this petroleum is to furnish carbon to the gas, petroleum itself being what is called a hydrocarbon, that is, composed largely of hydrogen and carbon. Now, hydrogen alone is not an illuminant; it burns with a pale blue flame. Every illuminant, whether candle, lamp, gas, or electric, depends upon incandescent carbon for its luminosity; carbon, then, is added to the gas to make its flame luminous.

Fig. 1.

The gases mingle with the petroleum spray and rise to the surface of the heated brickwork. Here the intense heat volatilizes the oil, which becomes chemically changed into various gaseous and tarry products.

After the steam-blast has been in operation for about 20 minutes, it is necessary to reheat the apparatus, so the steam-valve is closed and the air-valve opened. One charge of coal lasts through two complete charges of steam and air, or about 80 minutes. These figures vary considerably under different circumstances. The quantity of gas liberated at each coal charge is from about 12 to 15 thousand cubic feet. In the 24 hours of a winter's day, about 10 charges of coal are used.

The chemical action which takes place in the regenerator is called "fixing the gas." This hot fixed gas contains some tarry products which are condensable. These must be removed, or the gas-pipes would soon become choked. So the gas is passed through a sort of trap, filled with water. This cools it somewhat and also prevents any backward rush. It then enters what is called a "scrubber." There are various forms of scrubbers, but the main principle of them all is to bring the gas in contact with a constantly renewed supply of cold water. The cooling condenses the heavy tars and they flow out at the bottom of the scrubber. The gas is then passed through other condensers, similar in construction to the ordinary upright tubular boiler. The hot gas passes through the tubes, entering them at the top and passing out at the bottom. These tubes are surrounded by cold water, which enters at the bottom, under pressure, and flows out at the top. From one condenser the gas passes on to a second and sometimes to a third, and when it makes its final exit, it is quite cool.

The gas next passes into a system of pipe-works, through which it is diverted by means of valves into the purifiers. These purifiers consist of large flat iron boxes. They are arranged in sets of four. Three of them are always in use, the fourth being kept for a change-off during the cleaning of any one of the other three. Each box contains a mixture of oxide of iron, lime, and sawdust. The sawdust has no chemical effect, being added merely for the sake of keeping the lime and oxide of iron in a state of mechanical separation. The lime unites with the carbon dioxide and forms calcium carbonate. It also takes up some of the sulphur, forming sulphide of calcium. The remaining sulphur compounds are taken up by the iron oxide, and form sulphide of iron. The gas is now ready for use and passes into the station meter.

This consists of a large cylindrical vessel about 10 feet in diameter and 15 feet long. An exterior view is shown in Fig. 1. The interior is represented in Fig. 2. The vessel is a little more than half-full of water. The gas enters at *P* above the surface of the water, and passes into one of the four partitions of the drum, as shown. Its exit is cut off at *C* by the water, so it raises the partition; in other words, it causes the drum to rotate in the same direction as the hands of a clock. As the outer end of the partition emerges from the water at *D*, the gas escapes into the space between the drum and the external cylinder and passes out through a pipe not shown in the figure. This instrument is known as a wet meter and is an accurate index of the output of the

Fig. 2.

works, for it is operated entirely by the pressure of the gas; and since each partition holds a known amount, the total volume which passes through the meter may be measured by recording the number of revolutions. This is done by a mechanical counting device attached to the cylinder, the dials in front recording the number.

After escaping from the meter, the gas flows through pipes to the gas-holder shown in Fig. 3. This consists of an inverted vessel of sheet iron, which floats in a tank of water, and rises and sinks as the volume of gas in it varies. The pipe through which the gas enters, opens above the surface of the water, and another pipe placed on the opposite side provides for its exit. As the holder rises and falls, it is kept in position by the rollers or pulleys shown in the figure. The modern gas-holder is a triumph of mechanical skill. Much ingenuity has been expended in constructing a holder which would have the necessary strength, and still

be of light weight. There may be several cylinders, or lifts. As soon as one is filled, it hooks into a projecting flange on the next lower one and raises that. It is a very important part of the gasworks, as it accomplishes several purposes. It stores the gas

Fig. 3.

that is manufactured during the part of the day when there is little demand, and, when the gas is in use, forces it out with a nearly constant pressure by reason of its own weight. It also *mixes* the gas from different charges so that the product as sent through the mains will be of uniform illuminating power.

The amount of pressure in the mains is regulated by the "station governor." This instrument is so delicately constructed that the opening of 20 burners on the mains will cause it to automatically increase the supply. Near the governor is a **U** tube containing water. One arm is open to the air, and the other is subject to the pressure of the gas. The difference in height of the two columns indicates the pressure. In the office, an automatic register and pressure-gauge are in sight of the superintendent. These read the same as the **U** tube in front of the governor, and a breakdown is immediately discovered.

From the governor the gas passes out through the mains. Sometimes, when the mains extend a great distance from the works, an auxiliary holder is constructed, which regulates the pressure for that district. At the consumer's the gas is again measured by a small dry meter.

Let us now examine the flame of the burning gas. Just above the tip is the blue space marked *H* in Fig. 4. If we insert the end of a glass tube into this space, we may observe a deposit of water near the upper end. On the approach of a match the issuing gas will ignite. This blue area of intense heat and low illuminating power is burning hydrogen. It unites with the oxygen of the air and forms water, which condenses in the upper part of the tube. Along with the hydrogen come the hydrocarbons. They are decomposed in the dark space just above *H*—marked *C*—and the carbon is free. During its passage through the flame, it becomes incandescent, and then unites with the oxygen of the air to form carbon dioxide. When there is an excess of carbon or a deficiency of oxygen, all the carbon is not consumed, and it escapes in the form of soot. The dark fringe around the flame is caused by the condensation of the carbon as it meets with the cool air. If we raise the tube from its first position, until the end lies in the area of illumination, the little flame will go out, and in its place we will have smoke.

If a cold glass plate is brought near the top of the flame, a band of soot will be deposited upon its surface. If now we take a tube and blow through the flame horizontally at *H*, the entire flame will become blue. If we now hold the cold plate near this flame, no soot will be deposited, showing that the carbon has all been consumed. If a wire is held in this blue flame, it will become white hot in a few seconds, owing

Fig. 4.

to the intense heat produced by bringing plenty of oxygen to the flame, and consuming all the carbon. This is the principle of Bunsen burners and gas-stoves, in which air is admitted to the gas-pipe before it reaches the burner, is drawn along by the

motion of the gas, and furnishes to the flame an abundant supply of oxygen. The new gas-burner of the Welsbach type consists of an incombustible ash mantel which is heated to incandescence by a small Bunsen burner.

The rapid introduction of electricity as an illuminant has stimulated the gas manufacturer to the production of a better quality of gas, and the provision of means for its economical use, both as an illuminant and as a heating agent, and the time is possibly not far distant when gas will be used instead of coal or wood, for cooking our food and warming our homes.

THE ATMOSPHERE.

G. H. Dimpfel, Ph. D.

Its Composition and How Determined—Our Breathing Organs—We Live at the Bottom of an Aerial Ocean—Deep-Sea Fish—Ballooning.

OF ALL our surroundings, we are probably most familiar with that invisible something which we call *the atmosphere*, and which we are industriously engaged in pumping into our lungs "for dear life," every moment of our existence.

The atmosphere is the aerial envelope which surrounds the earth, and constitutes the ocean of air at the bottom of which we are living. The exact height of the atmosphere is unknown; it is generally given as from 30 to 35 miles; observations, however, upon the zodiacal light and meteoric showers lead us to believe that it may be from 50 to 60 miles.

Thanks to certain self-acting arrangements in the nervous system of the animal organism, the respiratory organs work mechanically and perform their unceasing labors so quietly and regularly that, as a matter of fact, we scarcely give a thought to them, unless, in some way or other, they get out of order. It hardly ever occurs to us that we are living and breathing at the bottom of an immensely deep aerial ocean, deeper and wider to an enormous extent than the watery oceans we are familiar with, and agitated by tides and currents and furious whirlpools, compared to which the disturbances of the watery oceans are the merest pigmies.

The first question which occurs to the thinking mind is, of what is this immense aerial ocean composed; what are the gases and what their proportions?

The exact composition of the atmosphere has repeatedly been made the subject of experimental research. It has been found that the air is a mixture of oxygen and nitrogen in the proportion, according to Dumas and Boussingault, of 23.13 of oxygen to 76.87 of nitrogen. It also contains a little less than 1 per cent. by volume of a gas, the existence of which has been recently discovered by Lord Rayleigh and Professor Ramsey, and named by them *argon;* traces of carbonic acid gas, and a variable proportion of vapor of water; in addition to these it contains traces of ammonia, and, under certain conditions, a little hydrogen disulphide.

Air has been brought from the lofty Alpine heights, and from the dry, overheated plains of Egypt; it has been brought from an elevation of 21,000 feet by the aid of a balloon; it has been examined in large cities, such as London and New York, and in small, out-of-the-way country places; still, astonishing as it may seem, the proportion of oxygen and nitrogen remains pretty nearly always constant. The presence of carbonic acid gas, however, being caused by local influences, varies somewhat.

That the atmosphere is a purely mechanical mixture of gases, and not a chemical compound, has and can be ascertained as well by analysis as by synthesis. The former method is the one by which Lavoisier first established the composition of air. His experiment, now a classic one in chemistry, was performed in the following way: A glass balloon with a long neck, as shown at *a* in Fig. 1, was partially filled with mercury. This was heated. The neck passed down under the surface of the mercury in an adjoining trough *b* and then up into a bell-glass *c*—also full of air—whose mouth was sealed by the mercury. On raising the temperature of the mercury in *a* to near the boiling-point, a red powder began to

accumulate upon its surface, the volume of the air in *c* at the same time proportionally diminishing, until, at the end of twelve days, the contraction of volume ceased, and the experiment was concluded. The gas contained in the apparatus was found to be nitrogen ; and, by collecting the red powder

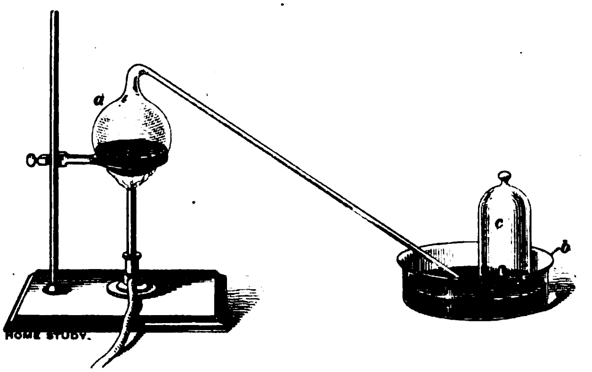

FIG. 1.

and heating it, the mercury was reproduced and a gas evolved, which proved to be oxygen.

This experiment, however, was purely qualitative, proving only the broad fact that air consisted largely of oxygen and nitrogen, mechanically mixed. An approximate quantitative experiment may be easily performed by taking a graduated tube full of air, placing in it a piece of phosphorus *p*, Fig. 2, fastened to the end of a wire, and immersing the mouth of the tube in a bowl of mercury. By the slow combustion of the phosphorus, the oxygen will be removed from the air, and the mercury will naturally rise to fill the space which the oxygen had previously occupied. The nitrogen will be left in the tube. Knowing the original volume of the air, its composition may be easily calculated from the increased volume of the mercury in the graduated tube.

A far more accurate quantitative analysis of air, however, may be made by means of a piece of apparatus known as an *eudiometer* (see Fig. 3). A measured quantity of air is placed in a eudiometer, and hydrogen is added in excess of that necessary to combine with the whole of the oxygen present ; on the passage of an electric spark, union of hydrogen and oxygen is effected, and on the gas regaining its original temperature, the volume is found to be much less. As water is composed of 2 volumes of hydrogen to 1 of oxygen, the amount of oxygen present in the gaseous mixture is one-third of the diminution observed. The eudiometer employed for this purpose should, of course, be graduated. Supposing that 10 cubic inches of air have been introduced and 5 cubic inches of hydrogen added ; after the explosion the volume will be found to be reduced from 15 to about 9 cubic inches ; 10 cubic inches of air, therefore, contain $\frac{6}{3} = 2$ cubic inches of oxygen.

The composition by weight is most exactly ascertained by passing air over red-hot copper, due precautions being taken to avoid error. The copper is placed in a piece of glass tubing, as shown at *d*, Fig. 4, with which it is weighed ; an exhausted receiver *b* is also weighed and attached to one end of this tube ; the other is connected with four **U** tubes, two of which are filled with caustic potash and two with sulphuric acid for removing the carbonic acid gas and water. The glass tubing *a* is raised to red heat, the stop-cocks of the receiver are opened, and a slow current of air passes over the copper ; its oxygen is removed and nitrogen only passes into the empty receiver. The gain in weight of the copper represents the weight of the oxygen, and that of the receiver the weight of nitrogen.

It has already been stated that carbonic acid gas is present in the atmosphere ; the breathing of animals and the burning of carbonaceous bodies are continually supplying this gas ; and although this operation is

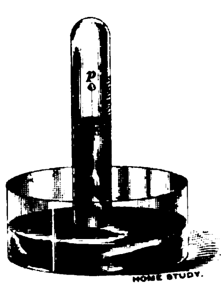

FIG. 2.

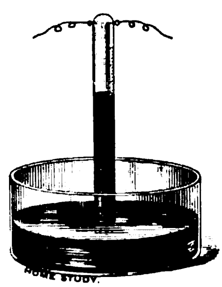

FIG. 3.

proceeding without intermission, the quantity of carbonic acid gas is practically constant. Its amount varies between 3 and 6 parts in 10,000, according to the locality where, and the time when, the gas is collected. This quantity, small though it may

appear, is of vast importance to the vegetable kingdom, being the source from which all organic carbon in nature is derived. Animals can only assimilate carbon from previously existing organic compounds. Vegetables decompose carbon dioxide, using the carbon in the formation of their tissues and liberating the oxygen in the free state.

The effects, therefore, of animal and vegetable life on the atmosphere are opposite in character: the one removes oxygen and returns carbonic acid gas, the other decomposes this compound and again yields oxygen to the air (this return action is, however, partially balanced by the ordinary process of decay); these two processes going on simultaneously, keep the proportion of carbonic acid gas in the air within certain limits. The decomposition of some rock-forming minerals, as feldspar, by the action of carbonic acid gas, which combines with the bases that they contain, is another important drain on the amount of this gas in the air.

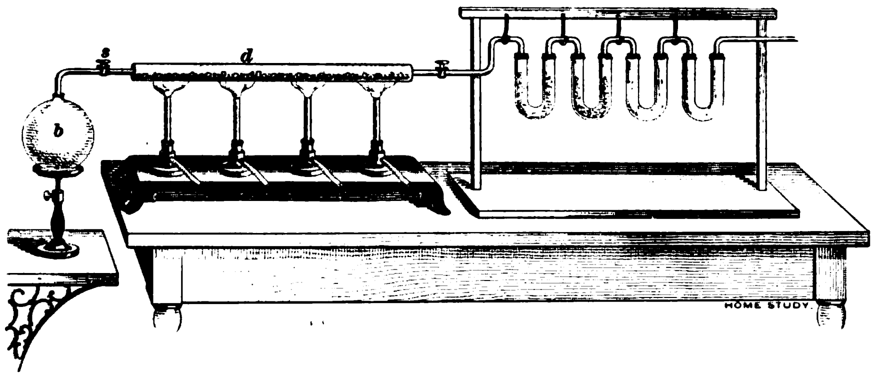

Fig. 4.

The amount of water vapor which the atmosphere contains varies considerably, but there is always more or less of this vapor present. Its presence may be easily demonstrated by bringing a vessel of ice-cold water into a room: the vapor condenses on the outside as a film of moisture.

Ammonia is only found in air in minute traces. These, however, are important, as from them the plants obtain a great proportion of their nitrogen.

Having now satisfied our curiosity in regard to the chemical composition of the atmosphere, an important physical question remains to be settled.

We often hear the question, Why do we not, as dwellers at such an immense depth in the aerial ocean, feel any sense of weight or oppression? It is a well-known fact that in the deepest parts of the Atlantic and Pacific oceans the pressure of the paltry four or five miles of water is sufficient to crush strong-closed vessels of metal or thick glass which may be attached to sounding-lines—a fact which may be easily understood when we stop to think that every fathom, as the mariner says, or in plain English, every six feet of water, means a pressure of about two and one-half pounds on every square inch of surface; so that when thousands of fathoms are in question, the pressure on every square inch runs well up into tons. This being so, it is quite clear that living creatures at such a depth, or even lesser depths, must be so constituted as to be able to stand the pressure upon them; and this they are able to do for the very simple reason that they are filled with fluid already compressed to the same extent as that outside them, and hence not liable to further compression, so that they are quite at their ease despite their enormous burden. Let, however, one of these denizens of the deepest sea yield to the temptation of the plummet, and mistaking it for a dainty morsel, pay the penalty by being hauled up with it to the surface, and what will then happen? Sad to say, long before the surface is reached, the outside pressure being reduced, the compressed fluids inside expand, and bang goes the entire economy of the poor, deluded aspirant to "realms above," where nothing but tatters and fragments arrive, as the result of the explosion.

We deep-sea fish of the aerial ocean find ourselves exactly in the same predicament, under similar conditions. Our bodies are permeated with fluids and gases all compressed to exactly the right degree by the

weight of the air above and around us. Hence, as a general rule, we do not feel any sense of oppression, notwithstanding that every square inch of us bears a weight of nearly fifteen pounds; though, doubtless, our feelings of discomfort under unusual conditions of the barometer may be imputed to this fine adjustment being slightly upset.

Let us, however, try to upset it a little more by chartering a balloon and imitating our hungry and dainty fishy friends. For a few thousand feet we will feel all right enough, and we can regard the prospect below with fair equanimity. Presently, however, our internal adjustment begins to go wrong; we begin, apparently, to swell—not, perhaps, so visibly as Sam Weller's young woman at the tea-meeting—but certainly enough to render us rather uncomfortable, and this swelling sensation goes on increasing the higher we rise, until, unless the balloon-valve is pulled in time, our veins burst their walls.

Between the aerial and the watery ocean there are, however, wide differences of condition, apart from the minor one of density. In the watery ocean it is the surface which forms the chief area of life and tidal activity. The water in the profoundest depth is nearly motionless, is wrapt in absolute darkness (so far, at any rate, as sunlight is concerned), and its temperature, even under the tropic sun, is at or very near freezing-point.

In the aerial ocean, on the other hand, though the greater lightness of air permits its currents to influence it from bottom to top, the chief area of life is at the bottom; light permeates it freely, and while the temperature at the bottom may be high, it is only necessary, even in tropical countries, to ascend a comparatively few thousands of feet to find not merely that the freezing-point is reached, but that the higher we climb the colder it becomes, until, finally, could an unexploded mortal manage to reach its limits, the inconceivable cold of space itself would be encountered. These opposite conditions are both due to one and the same cause. It is the life-giving rays of the sun, which, refusing to part with their heat to the air, and unable to penetrate beyond a short distance into the water, confine their beneficent warmth to the earth's surface as the bottom of the aerial ocean, and the surface of the seas as the uppermost limit of the watery one.

CURRENT TOPICS.

Mrs. F. R. Honey.

THE WAR IN INDIA.—Another war in India! It is barely three years since the last one was fought. Why does the world so frequently hear of war in India? Why are the British there at all? Why should that small island, Great Britain, continually obtrude itself on the public eye, and be involved in disturbances far from her own shores? Such questions are often asked, and the incidents of the present time suggest an answer.

The island of Great Britain is not the British empire. The British empire includes Great Britain, her family, the colonies, and her great dependency, India, to whom she is, on the whole, a kind and careful stepmother. And in such a large family, so widely scattered, with such diverse interests to develop and protect, occasional disturbances must inevitably take place, unless, indeed, the empire becomes a Utopia, and guardian angels descend to be her governors!

And why are the British in India? Americans, with British blood in their veins, with British traditions behind them, and history which bids fair to rival that of Britain before them, recognize the irrepressible power of expansion that belongs to nations of the Anglo-Saxon race, so that wherever on the face of this earth they gain a foothold there they stay and take possession, whether they are Americans subduing and exterminating tribes of Indians, or British establishing their rule over millions of East Indians. That is why the British are in India. And if they were not there what would have happened? It is incredible that in these days a fertile and accessible, but ill-governed, country would have been left to itself, torn by internecine wars, ignorant of the arts by which commerce may be developed and its products made to contribute to the wealth of the world.

There was a time when France, Holland, and Portugal were England's rivals in India. Would the world have been any better off if either of those nations had won the prize?

For good or for ill, however, the British are in India; and before the causes and incidents of the present frontier war are considered, it will be interesting to glance at the history of the conquest and occupation of this Asiatic peninsula.

Not long after Columbus had sailed westward and discovered America, a Portuguese navigator, Vasco da Gama, sailed eastward and discovered the water-route from Europe to India, round the south of Africa. Before his time India could only be reached by a long, dangerous, and difficult land journey. The mountains which divide her from the rest of Asia are quite impassable, except at a very few points on the northwestern frontier; and through these passes, between the territories now known as Afghanistan on the one side, and the Punjab on the other, have poured the armies which in past ages have entered India, and there acquired dominion for their masters. Many such invasions have taken place; for India, from the earliest times down to the days of the Nabobs, who made their fortunes there a few generations ago, has been regarded as a mine of wealth.

The sixteenth century was a great period of maritime adventure, and when once Vasco da Gama had shown the way, the ships of Europe became familiar objects on the shores of India. England, France, Holland, and Portugal made settlements on the coasts, and carried on trade with the natural and manufactured products of the country. None went there with the desire or intention of conquest. The first ships carried no soldiers, but merchants, who had arms sufficient only to defend themselves and their goods, and who expected and desired to sustain friendly relations with the native races. The East India Company of England, which was eventually to obtain control of the country, was formed in 1599 by a few London merchants who objected to the high price which Dutch traders put on Indian pepper, a point about which they certainly did not intend to fight!

If only one nation had settled in India her destiny might have been very different. But during the eighteenth century England and France, who kept well abreast in the race for commercial power in Asia, were frequently at war, and part of their quarrel was fought out in India, with the aid of native troops on both sides. For India is not a single country, inhabited by one race, and speaking one language. It is, like Europe, a vast territory, divided among many governments, with a variety of peoples and of tongues. It was easy for England and for France to secure allies from tribes which were themselves at enmity, and had feuds of their own to settle. The fortune of war, the political conditions at home, and the superior military skill of the English leaders at a critical juncture, combined to decide the contest for supremacy in England's favor. The East India Company, with the protection of trade and commerce as its main object, continued to make treaties with friendly tribes, and to fight those who were unfriendly—always with the aid of native troops—until large sections of the country were under its control.

As long as anything has been known in detail of the history of India, she has been the prey of invading races. The Marathas, who had gained the upper hand in the eighteenth century, were cruel and tyrannical; robbery and violence prevailed and were unpunished, and organized resistance on the part of those whom they oppressed seemed impossible. This state of things could not continue in the presence of a powerful European race whose commerce was liable to injury and even to ruin from these internal troubles, and who had learned by experience that native troops would fight faithfully under foreign commanders when well paid and well led; and after many years of alternate peace and conflict, the East India Company found itself the ruler of the greater part of the country.

It should always be remembered that this conquest was not made by England as a nation; but that a trading company, beginning business in a very small way, by degrees acquired this rich prize, and handed it over to the mother country only when its government became too great a matter for private management. Great Britain, a small island in the North Atlantic, could never have dreamed of conquering India, a vast territory many thousand miles away, had she been opposed by a united people fighting for their fatherland. She has become possessed of this great dependency by other means than by brute force, and by other means she must hold it, if her power is to endure. The means by which she proposes to hold it are the maintenance of *pax Britannica*, "Britain's peace," so that every man's life and property may be safe; the

equal administration of justice, irrespective of color or of race; just taxation, amounting to less than one-half of that which used to be paid to native rulers, and of which every rupee is spent on the defence, the government, and the development of India; the spread of education; the introduction of those products of modern civilization, railroads, telegraphs, canals, and good roads, which may aid in the advancement of the country and of the people. She has made many mistakes, many failures in judgment, many blunders; and the agents of the East India Company in the early days of its power committed some crimes which have been much exaggerated, and have never been forgotten. But some of the best and ablest men of the century have spent their lives in India, working with a single eye to the good of the country, and endeavoring to promote the happiness and welfare of the people among whom their lot was cast.

Since 1858 England has had to solve a problem such as the history of the world has never before presented: the peaceable government of two hundred and twenty-five millions of people, who, in race, in language, in religion, and in customs, differ not only from their rulers, but from one another. She has pledged herself not to interfere with any form of religion, except when actual crime is involved in its practice, such as the burning of widows or the murder of infants; nor with the customs and the caste-rules, which sometimes, as in the case of the recent plague in western India, render the enforcement of sanitary regulations extremely difficult. About one-third of the area of India is still ruled by native chiefs, who reign over their subjects almost as independent sovereigns, and have revenues and armies of their own. They have all, by treaty, acknowleded the British government as the paramount power, and have agreed not to make war upon each other, or to form alliances with foreign countries. At each native court there is a British resident, who, in cases of gross cruelty or misrule, interferes for the protection of the weak and for the maintenance of peace.

The country in which this problem of government is to be dealt with is one which, by its geographical position, is liable to an irregular rainfall, producing uncertain harvests, so that occasional famines in some districts are regarded as inevitable. The greater peace and security of the country under British rule have caused the population to increase with rapidity, and thus the distress arising from plague and famine is great in proportion to the large number of people affected by these calamities.

It may cause surprise that the Hindus submit thus quietly to be governed by an alien race, but it should be remembered that the mass of the people has for many generations been subject to foreign dominion. The sentiment of national independence may, therefore, be said scarcely to exist among them. So long as their persons and their property are protected, and their religion and their customs are respected, they care little who administers the law under which they live. The population includes about sixty millions of Mohammedans, of whom a part are descended from the races that were in power before the English were established in India, and were dispossessed by them. These still retain the memory of their predominance, and are of a more vigorous and combative character than the Hindus. They are less submissive to the restrictions of the British government, and if serious trouble should arise it will probably be caused by this section of the population, rather than by the native races, among whom, however, there are a large number of Mohammedans.

During the last half-century there has been but one outbreak in the country itself, the mutiny of 1857; and terrible as that was, it was confined to one part of India, and mainly to one class of the inhabitants. The other Indian wars that have occurred have been with frontier races, who endangered the peace of the country either by quarrels among themselves or by attacks on the borders of the British dominions. Such a frontier war is the one now in progress in the mountainous region which divides British India from Afghanistan, and from the part of Asia which is recognized as being within the sphere of Russian influence. This war will be the subject of next month's paper. It is more than a mere conflict between semicivilized tribes, who are entrenched in a strong natural position, and a foreign race which is as certain of eventual success as is the army of the United States when war is carried on against the Indians in this country. Its real importance lies in the fact that it is a struggle on the border-line between the two great European powers, Great Britain and Russia, who are now predominant in Asia, and whose relations to one another in that part of the world will probably be one of the main features of the history of the twentieth century.

THE COOKING OF WHOLESOME MEALS.

Mrs. Henry Esmond.

An Inexpensive But Tasty Supper—Useful Hints on Preparing Creamed Potatoes, Baked Apples and Jelly Roll—A Good Cup of Cocoa.

WHAT shall we have for supper? Many a good housewife knits her brows and looks uncommonly serious, trying to decide. She knows that after a hard day's work a man is none too easy to please. Breakfast *never* worries her, dinner seldom, but with supper it is different. Let us see what can be done with the cold roast beef left over from dinner, helped out with sundries.

BILL OF FARE FOR SUPPER.

Roast Beef Cooked with Gravy.
Creamed Potatoes.
Biscuits. Cocoa.
Baked Apples. Jelly Roll.

Roast Beef with Gravy.—Cut in small pieces cold roast beef, removing the fat and any stringy portions. Put the meat into a frying-pan (if there is any of the thick gravy put it in with the meat), add 1 cup of cold water, cover and let it stew for 10 minutes, or until the water is colored with the meat juice. Now add 2 rounded tablespoonfuls of flour moistened with 4 tablespoonfuls of cold water; stir well to prevent lumping. Add a dash of pepper and ½ teaspoonful of salt. Pour it over small squares of toast which have been moistened with hot water and buttered. Roast lamb may be prepared in the same way. One teaspoonful of Worcestershire sauce or 2 tablespoonfuls of tomato catsup heighten the flavor. This, if desired, can be prepared in the chafing-dish.

Creamed Potatoes.—As the boiling of potatoes has been explained before, it is not necessary to repeat. Cut 6 medium-sized, cold, boiled potatoes into cubes ½ inch square. Put 1 tablespoonful of butter into a saucepan and, when it is melted, add 2 tablespoonfuls of flour; mix well, then add, slowly, 1½ cups of cold milk. The milk should be added a very little at a time, and if it lumps, the pan should be removed from the fire and the contents beaten vigorously. This should be repeated each time the milk is added. When all the milk is in, add ½ teaspoonful of salt and the potatoes; cook for five minutes. Chopped parsley is a very good addition.

Cocoa.—To 3 cups of milk add 1 of water. Let it heat, but not boil. To each cup of liquid use 1 good teaspoonful of cocoa. Mix it to a smooth paste with boiling water. Then add a little of the hot milk. When all the lumps are gone, pour it into the remainder of the milk. Add to this 1 tablespoonful of sugar to each cup of milk. Let it just come to the boiling-point; move the saucepan to the back of the stove and beat the cocoa with the egg-beater. Let it remain on the fire for 10 minutes. Be careful to keep the saucepan covered. otherwise a thick, tough skin will form on the top of the cocoa. The addition of ½ teaspoonful of vanilla is a great improvement.

Biscuits.—To a quart of sifted flour add 1 level teaspoonful of salt and 2 teaspoonfuls of baking powder. Sift into a bowl and add 2 tablespoonfuls of shortening, 1 of lard, and 1 of butter. Rub in quickly with the tips of the fingers. When the shortening is all mixed in, moisten with 1½ cups of sweet milk. More milk may be needed, as the dough should be as soft as possible; the softer the dough, the lighter the biscuits. Turn out onto a well-floured board and pat out lightly with the rolling pin. Cut with a small cutter or an ordinary glass, which has first been dipped in flour. Place close together in a pan and bake in a hot oven 12 or 15 minutes.

Baked Apples.—Core and pare 6 good-sized apples; put them in a pie-pan or a round cake-pan. Put a small piece of butter into the hole in the center of each apple; then fill it up with granulated sugar. Pour ½ cup of boiling water into the pan and bake in a hot oven 25 or 30 minutes. When done, leave in the pan until they are nearly cold, as the apples do not break so easily when cool as when they have just come from the oven.

Jelly Roll.—Beat together 1 cup of granulated sugar and the yolks of 3 eggs, and 2 tablespoonfuls of milk. Sift into this 1 cup of flour, to which has been added 1 teaspoonful of baking powder. Mix the flour in

lightly, then add the whites of the eggs (which have been beaten stiff), and 1 teaspoonful of vanilla. Bake in an oblong pan in a moderately hot oven. Do not let it get too brown. Ring a cloth out of cold water and spread it on the pastry-board. When the cake is done, turn it out onto this cloth. With a sharp knife, that has been dipped into hot water until thoroughly heated, cut the cake into three slices. The reason for using the wet cloth is that it keeps the cake moist and makes it easier to roll. Whenever hot cake or bread is to be cut, use a hot knife, as this keeps the bread from becoming soggy. Spread the cake (one slice at a time) with sour jelly, either currant or grape. Roll up the cake and tie loosely with string, otherwise it will unroll; wrap it up in the damp towel. This keeps it moist.

NOTICES.

IMPORTANT.

THE following information is for the benefit of those who send questions to the Answers to Inquiries Department:

* All letters containing questions should be addressed to the Editor of "HOME STUDY MAGAZINE," Scranton, Pa.; and this address should appear not only on the envelope but also *at the head of the letter itself.*

* Under no conditions will questions be answered by mail.

* If a stamp is enclosed, we will acknowledge the receipt of the inquiry and inform our correspondent in what number the answer may be expected to appear.

* Questions that are for any reason unsuitable for the Answers to Inquiries columns will be promptly returned to the sender.

* Write on one side of the paper only and make drawings for illustrations on *separate* paper. Take pains to make your drawings and sketches as clear as possible.

* For our information, and not for publication, names and addresses must accompany letters or no attention will be paid to them. The full name will not be published under the question asked, but only the initials of the writer's name and the name of the town or city from which the letter is received. If the party asking a question does not wish his initials to appear, he should let us know what letters to use.

* References to former answers should give date of paper and number of question.

* Letters sent to correspondents, under cover to the Editor, will not be forwarded, and the names of correspondents will not be given to inquirers.

* Buyers wishing to purchase any book or other article not advertised in our columns will be furnished with addresses of houses carrying the same.

* Books referred to promptly supplied on receipt of price.

* Minerals sent for examination should be distinctly marked or labeled.

A NEW BOOK.

HOW TO BUILD A HOME—THE HOUSE PRACTICAL. By Francis C. Moore. 12mo, decorated board cover. Published by Doubleday & McClure Co., New York, 1897. Price $1.

In his preface to this book, Mr. Moore informs us that, as an amateur, he made a study of construction for a quarter of a century, and that when he finally came to build a house for himself he submitted his plans to architects, carpenters, masons, and other practical men with whom he enjoyed acquaintance, the result being that he is now able to say, after living in the house, that, if he ever has to build again, he will use the same plans.

In this book we are told in a very agreeable and instructive manner how the House Practical—that is, the durable, healthful, comfortable, convenient, and approximately fire-proof house—may become also the House Beautiful.

A practical example is given, in which are complete plans in detail of a spacious and convenient summer cottage which can be built for a comparatively small sum.

ERRATUM.

January Number.—Article, "Napier," the word *exponents* in the second line should be *logarithms;* the first paragraph then reads:

"The following laws, which govern all operations with logarithms, are easily deduced from the laws of exponents."

(1) Can you tell me whether lard-oil that has been used can be cleaned and used again? Can you explain the process? G. R., Rockford, Ill.

ANS.—Filters are in use for cleaning and rendering fit for further use such oils as rape, cottonseed, and mineral oils after being used in steam-engines and machinery; we are not informed as to whether the same treatment is suitable for lard-oil.

***

(2) (a) I have a duplex compound-condensing pump with steam-cylinders 14 inches and 26 inches and water-cylinders 18 inches in diameter, all with a stroke of 18 inches. The pump works against an average water-pressure of 60 pounds per square inch, with an average suction of 3 feet. The steam pressure at the pump is 85 pounds, at the boiler 90 pounds. What will be the horsepower when the pump makes, respectively, 10, 20, and 40 revolutions per minute? (b) With a water-pressure of 100 pounds there is a pressure of 60 pounds in the steam-chest. What is the horsepower for these pressures?
A. W. W., Sterling, Ill.

ANS.—(a) Computing the horsepower from the pressure against which the pump works, and allowing 20 per cent. of the total power for frictional losses, the pump requires 18 horsepower to drive it at 10 revolutions per minute, 36 horsepower at 20 revolutions, and 72 horsepower at 40 revolutions. (b) Computing the power in the same way as before, the horsepowers will be: for 10 revolutions 30 horsepower, for 20 revolutions 60 horsepower, and for 40 revolutions 120 horsepower.

***

(3) What causes butter to stick to some parts of the sides and flail of an oak churn?
C. K. S., Wayland, Iowa.

ANS.—This question does not belong to any branch of engineering. It is rather one that the experienced dairyman should answer for himself. The conditions of the weather and the temperature of the cream no doubt have something to do with it, and so, probably, has the nature and grain of the wood of which the churn is made, but it is impossible for us to give any specific reason

***

(4) (a) How can the weight of smoke be ascertained? (b) Is it correct to say that the inertia of a locomotive is greater, the higher the boiler is raised from the ground, that is, the larger the wheels are upon which it runs? J. B., Fredericksburg, Va.

ANS.—(a) Take a flask of known capacity, exhaust the air from it and then weigh it. Next fill the flask with the smoke to be tested and weigh it again. The difference in the two readings will be the weight of the smoke. (b) The inertia of a body, in the general acceptation of the term, depends only on its mass or, popularly speaking, its weight. Raising the boiler of a locomotive does not increase the inertia of the latter. The higher the center of gravity of a body is lifted above the ground, the more effect a given force will have in tending to overturn it, but this is not due to increased inertia. As you seem to imply, the size of driving-wheel is one of the determining factors in the height of a boiler.

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ANS.—(a) It is customary in designing such a trestle to place the bents 12, 14, or 16 feet apart, center to center, according to the surface conditions and the length of timber that can be most readily obtained. (b) In the designing of trestles, the load, the width of the trestle-floor, and its height above the ground are all the factors the engineer works from. The usual batter given to the outer legs is 1½ inches per foot of vertical height. The legs are boxed or gained ½ inch into the cap and sill, besides being mortised and pinned at each end. The bents are sway-braced as shown in the accompanying illustration. Longitudinal bracing is also used to tie the bents together. We have marked upon the sketch the proper sizes of all the bent timbers, in the case cited; also the sizes of stringers for a span of 16 feet, center to center. The stringers should be so laid as to be under the rails, butting against each other, end to end, and tied together by splice pieces. (c) There is no fixed rule for calculating the lengths of caps and sills, but it is usual to make the length of the cap equal to the width of the platform; then add to the length of the cap ¼ of the vertical height between the cap and sill, for the length of the sill. (d) It is best in this case to use oak for the flooring and stringers, and white pine for the remainder.

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(6) In order to fill a locomotive-boiler preparatory to firing up, we placed another locomotive with a full tank of water and a full head of steam (140 pounds) on an adjacent track. This locomotive was equipped with a No. 10 Nathan Monitor injector,

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see notice on opposite page.

the branch-pipe of which we connected to the "dead" engine, the pop-valve on which was set to blow off at 190 pounds. When the boiler of the "dead" engine was partly filled, this pop-valve blew off and the steam gauge registered 190 pounds. Please explain how it is that with but 140 pounds pressure supplied to the injector, a pressure of 190 pounds can be produced. M. A. K., Mauch Chunk, Pa.

ANS.—As the empty boiler was filled, the air in it was compressed until the pressure reached the blowing-off point, 190 pounds per square inch. To reach this pressure, the air must have been compressed to $\frac{1}{13}$ of its original volume, that is, the boiler must have been $\frac{12}{13}$ full of water. There should be no trouble in forcing water into a boiler against a pressure of 190 pounds if the steam-pressure is 140 pounds. The ordinary exhaust-steam injector is fed with steam at about 17 pounds pressure and can force water into a boiler against 80 pounds pressure. The work required to force the water against the excess of the pressure is supplied by the heat of the entering steam, and is in any case only a small fraction of the total heat that might be supplied by the steam.

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(7) I have a 2-horsepower gasoline-engine and would like to know if you will furnish me with plans and description of a suitable carbureter for use with same. S. G. M., Montclair, Col.

ANS.—A carbureter, or mixing valve, is illustrated and described in the article "Gas-Engines" in this month's (February) issue of HOME STUDY MAGAZINE. As this is a patented device, you will have to obtain permission for its use of the manufacturers, The Sintz Gas-Engine Company, Grand Rapids, Mich.

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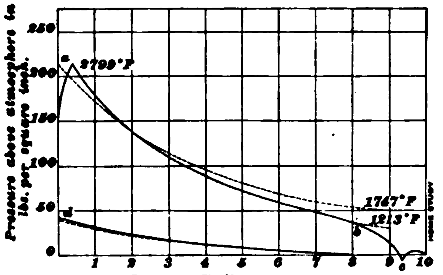
(8) In an ordinary gas-engine: (*a*) What is the pressure at the time of explosion? (*b*) What is the pressure when the piston has reached the end of its stroke just before exhaust begins? (*c*) Do the gases developed by the explosion expand as readily as steam? (*d*) What is the pressure on the compressed gas just before explosion? (*e*) Is there any metal or alloy that will not scale or burn, in consequence of the intense heat developed in a gas-engine?
R. W. E., Alvarado, Cal.

ANS.—(*a*, *b*, and *d*) In the accompanying figure, which is an average gas-engine card, *a* is the pressure of explosion, *b* that just before exhaust, and *d* the



pressure after compression. (*c*) Yes. (*e*) We know of no such metal. Gas-engine cylinders are usually surrounded by a water-jacket to prevent overheating. In HOME STUDY MAGAZINE there is now appearing a series of articles on gas-engines. This series commenced in the December number, 1897.

***

(9) (*a*) I am anxious to construct a furnace from which, by the combustion of Connellsville coke, a full equivalent of carbon dioxide gas can be obtained; can you tell me of any text-book or authorities on the subject? (*b*) If I take an ordinary heating stove, is it necessary to admit air *over* the burning coke, or will sufficient oxygen be admitted if the draft underneath the grate is open? (*c*) How can I be sure that enough oxygen is being furnished to make carbon dioxide instead of carbon monoxide? (*d*) How can I adequately purify the gas? (*e*) What pumping force is necessary to remove gas to a receiver as fast as it is generated, assuming 100 pounds of coke as a charge?
E. H. A., Mount Vernon, N. Y.

ANS.—(*a*) "Fuel, Its Combustion and Economy," by D. K. Clark, will give you a great deal of information on this subject. (*b*) If the bed of fuel on the grate is not too thick it will not be necessary to admit air over the burning coke. (*c*) It will be necessary to have the gases analyzed. (*d*) The dust and some of the sulphur can be removed from the gas by washing. It will be impossible to separate the carbon dioxide from the nitrogen and other gaseous products of combustion by any simple process. (*e*) This question is too indefinite for us to give a complete answer. The pumping force will depend on the rate at which the gas is produced and the pressure in the receiver.

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(10) (*a*) What will be the effect on boiler-sheets and tubes if the feed-water is strained through bituminous coal? (*b*) Will steam-pipes give out any more heat if the pressure of the steam in them is increased? W. H., Williamstown, Mass.

ANS.—(*a*) Most bituminous coal contains sulphur, which would be absorbed by the feed-water and corrode the sheets and tubes. (*b*) Yes. The temperature of the steam in the pipes increases with the increase in pressure, and the amount of heat given off by a hot body increases with an increase of temperature.

***

(11) The article in HOME STUDY MAGAZINE entitled "Wonders of Pressure, Heat, and Cold" is of great interest to me, and must be of value to many. There are some points I do not understand and would be glad if you will explain them. You say that a column of air reaching 5 miles below the level of the sea produces, by its own weight, sufficient heat to melt steel. In trying to verify this from other information you give in the article, I cannot get such a heat. Please explain. C. A. J., Everitt, Mass.

ANS.—As the pressure of air, in common with other gases, varies directly as the weights of equal volumes, then, when the density of air becomes such that a cubic foot weighs 62.5 pounds instead of .0766 of a pound at atmospheric pressure, the pressure must be equal to $\frac{62.5}{.0766} = 816$, nearly; that is, it requires a pressure of 816 atmospheres to compress air at 62° F. to a density equal to that of water. As the temperature of air increases as its volume reduces, the increase of temperature, due to 816 cubic feet of air being compressed into the volume of 1 cubic foot, can be found, and the following formula can be used to determine it.

Let n = number of atmospheres;
14.7 = atmospheric pressure in pounds per square inch;
and T = temperature after compression.

Then
$$T = \left(\frac{81\,n}{\sqrt[5]{n}}\right) + 62.$$

Applying the formula, therefore, to the case before us, we have
$$T = \left(\frac{81 \times 816}{\sqrt[5]{816}}\right) + 62 = 17{,}353.67^\circ \text{ F.}$$

As the average melting temperature of steel is equal to 2,600° F., it follows that $\frac{17{,}353.67}{2{,}600} = 6.674$: that is, the temperature due to compression is 6.674 times greater than that required to melt steel. But, as the excessive temperature of compression would reduce the density of the air, and as much of this

heat would be absorbed by the encasing rocks, it was not claimed that more heat would be retained than would melt steel.

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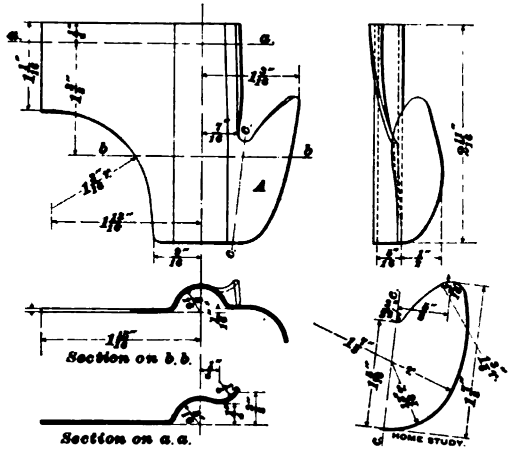
(12) I have sent you a small forging of which I am unable to make a working-drawing. May I ask



Development of A from line c.c.

you to do this for me, and to return the forging to my address? E. M. R., Dayton, Ohio.

ANS.—The above is a working drawing of the piece you sent us, with all necessary dimensions marked thereon.

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(13) Referring to the article "The Prony Brake," which appeared in HOME STUDY MAGAZINE for July, 1897, I would like to know how much pressure (which from your illustration is regulated by thumb-screws, and, therefore, cannot be great) should be applied to the parts that embrace the pulley also. What would be the effect of increasing or decreasing that pressure? M. E. O'C., Porter's Mills, Wis.

ANS.—The pressure applied by means of the thumb-screws is regulated by trial, the idea being to keep the pressure just sufficient to give the normal load at the given speed. Supposing the brake to be applied to an engine fly-wheel, if the pressure is increased, the load is increased in proportion, and the engine will slow down. If the pressure is decreased, the effect is to diminish the load on the engine, in which case it will run faster unless restrained by the governor.

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(14) (*a*) What is the best way to prevent steel from rusting? (*b*) What is the best way to remove rust from steel? (*c*) How can I remove ink stains from paper? J. R. B., Fredericksburg, Va.

ANS.—(*a*) We do not know the *best* way. A *good* plan, however, is to apply to the surface a mixture of tallow or lard and thick white-lead paint. (*b*) To remove rust from steel, immerse the article to be cleaned for a few minutes in a strong solution of cyanide of potassium, say in the proportion of about ½ ounce in a wine-glassful of water; take out and clean with a brush, using a paste composed of cyanide of potassium, castile soap, whitening, and water; these last are mixed in a paste about the consistency of thick cream. (*c*) Mix oxalic acid and tartaric acid in powder. Dissolve a little in water and apply to the ink stains. The preparation is poisonous.

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(15) Our water supply is obtained from four bored wells of 8-inch diameter and 50 feet deep. Each well is supplied with a 15-foot strainer, which lies in a gravel stratum. The tops of the wells are plugged and the pump with its suction-pipe is tapped into the well-pipes 12 feet below the top of the wells. The water is pumped 7 miles against a head of 300 feet. Now, the water contains too much iron, and after standing a few hours a red substance settles in it. (*a*) Is it the iron that settles in this way? (*b*) Is it expensive to filter water, as laundry companies do, by pumping it through a cylindrical vessel in which are chemicals for purifying it? (*c*) Our pump has a maximum pumping capacity of 1,200 barrels per hour; how would you advise us to get rid of the red substance? Of course we want to do it with as little expense as possible. (*d*) What kind of filtering process would rid the water of *all* its impurities? J. H. Mc., Richmond, Mo.

ANS.—(*a*) It is impossible to tell you with certainty whether the red sediment is iron or not, without testing it. However, we believe that the water passes through a stratum of ferrous clay and carries with it these ferrous impurities partly dissolved, which, when the water stands for some time, settle down to the bottom of the vessel. (*b*) The expenses are slight, after either a large filter is purchased or the basin excavated. (*c*) There are two ways to get rid of these impurities: (1) To run it through a filter containing charcoal. (2) To collect the water in a large basin, similar to those used for purifying the water supply of cities, that is, in an excavation in the ground with a bed of gravel about 2 or 3 feet deep. The exit of the water must be so arranged that the water always retains a certain level. (*d*) There is no filtration process to remove *all* impurities of water; to obtain chemically pure water it has to undergo distillation. Filtration through charcoal, however, is, for general purposes, quite sufficient.

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(16) (*a*) What is the cause of the most disastrous boiler explosions? (*b*) How much water will one pound of good coal evaporate in a correctly designed and skilfully fired boiler? L. A. D., Brighton, Ill.

ANS.—(*a*) Boiler explosions are caused by over-pressure of steam. Either the boiler is too weak to stand the ordinary working-pressure, or the pressure rises to a dangerous point on account of a defective or inoperative safety-valve. The most disastrous explosions occur when a new and strong boiler is ruptured by a pressure far above the working-pressure, and when the boiler contains a large body of water. A boiler which contains a small quantity of water rarely produces a very disastrous explosion. (*b*) From 9½ to 11 pounds from and at 212°.

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(17) Which is the more economical for feeding a boiler—the steam-pump or the injector? L. R. B. R., East Plymouth, Ohio.

ANS.—The injector is always more economical as a boiler-feeder than the steam-pump. Sometimes, for practical reasons or as a matter of convenience, it is advisable to use a pump for feeding a battery of boilers, the question of economy being a secondary consideration.

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(18) (*a*) Is a boiler strained as much by a cold-water pressure of 150 pounds per square inch as by a steam-pressure of the same amount? (*b*) How can I calculate the stresses under the two conditions? A. P. A., Fairmont, Minn.

ANS.—(*a*) The cold-water pressure strains the boiler as much as the steam-pressure. However, the worst stresses to which the boiler is subjected are

due to unequal expansion and contraction, and these stresses are not set up when the boiler is subjected to water-pressure. Consequently, the fact that a boiler safely withstands a water-pressure of 150 pounds per square inch does not necessarily prove that it will safely withstand an equal steam-pressure. (*b*) The stress in the shell-plate of a cylindrical boiler is given by the formula, $S = \frac{p\,d}{2\,t}$

where p = pressure;
d = diameter of shell;
t = the thickness of plate,

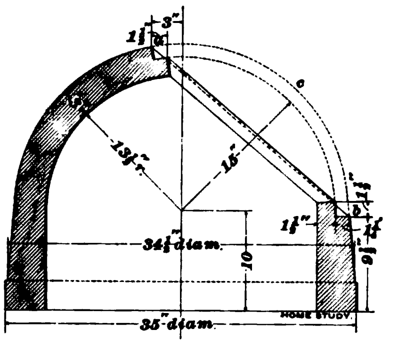
all dimensions being in inches.

For example, if the pressure is 150 pounds per square inch, the diameter, 60 inches, and the thickness, $\frac{3}{8}$ inch, the stress in the plate is $\frac{150 \times 50}{2 \times \frac{3}{8}} = 10{,}000$ pounds per square inch.

* * *

(19) I wish to fit a circular door 1¼ inches thick into a hole in the casting shown. How can I make a lay-out of the hole in the casting so that a circular door will fit it accurately? L. P. M., Philadelphia, Pa.

ANS.—Your inquiry is rather vague, as it leaves us in doubt as to whether you have made the door and wish to cut a hole in the cast-iron dome to fit it, or *vice versa*. We presume, however, that the hole was *cast* in the dome, and that you wish to make a cast-iron door to fit it. If this is so, make a full-size drawing like the accompanying figure, and measure all dimensions and angles from it, not forgetting to allow for shrinkage when making



the pattern. In order that the door shall fit the hole accurately, the hole must be machine-finished and the door turned up on the edge. We have supposed that the dome is a half sphere.

* * *

(20) In the enclosed sketch, $AB = 800$, $AC = 600$, and $BC = 400$. How can PA be found? A. W. B., Miles Grove, Pa.

ANS.—If A, X, and B, Fig. 1, are three collinear points, and Q any fourth point, we have the following fundamental and very important trigonometrical relations:

$$XB \cot A - AX \cot B = +AB \cot n. \quad (1)$$
$$XB \cot l - AX \cot m = -AB \cot n. \quad (2)$$

For,

$$QX = \frac{AX \sin A}{\sin m} = \frac{AX \sin A}{\sin (n - A)} = \frac{AX}{\sin n \cot A - \cos n}$$

And

$$QX = \frac{XB \sin B}{\sin l} = \frac{XB \sin B}{\sin (n + B)} = \frac{XB}{\sin n \cot B + \cos n}$$

Therefore,

$$\frac{AX}{\sin n \cot A - \cos n} = \frac{XB}{\sin n \cot B + \cos n}$$

Hence, formula (1) is obtained by an easy transformation. Again:

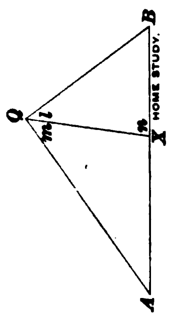


FIG. 1.

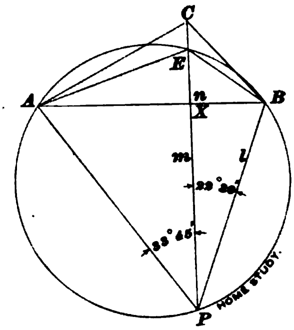


FIG. 2.

$$QX = \frac{XB \sin B}{\sin l} = \frac{XB \sin (n + l)}{\sin l} = XB(\sin n \cot l + \cos n),$$

and,

$$QX = \frac{AX \sin A}{\sin m} = \frac{AX \sin (n - m)}{\sin m} = AX(\sin n \cot m - \cos n).$$

Equating these values of QX and transposing, we get formula (2). Apply formula (1) to the triangle ABC, and formula (2) to the triangle ABP in Fig. 2. Then, by addition,

$$XB(\cot A + \cot l) = AX(\cot B + \cot m),$$

and

$$AX + XB = AB.$$

Whence,

$$AX = \frac{AB(\cot A + \cot l)}{\cot A + \cot B + \cot l + \cot m},$$

and,

$$XB = \frac{AB(\cot B + \cot m)}{\cos A + \cot B + \cot l + \cot m}$$

Substituting in (1), we get,

$$\cot n = \frac{\cot A \cot m - \cot B \cot l}{\cot A + \cot B + \cot l + \cot m}$$

Therefore,

$$\sin n = \frac{\cot A + \cot B + \cot l + \cot m}{\sqrt{(\cot A + \cot B + \cot l + \cot m)^2 + (\cot A \cot m - \cot B \cot l)^2}}$$

From the triangle AXP we have,

$$AP = \frac{AX \sin n}{\sin m} = \frac{AB(\cot A + \cot l)}{\sin m \sqrt{(\cot A + \cot B + \cot l + \cot m)^2 + (\cot A \cot m - \cot B \cot l)^2}}$$

which gives $AP = 910.28$.

* * *

(21) How can I make application for a patent direct to the patent office without employing a patent attorney? J. S. McC., Vincennes, Ind.

ANS.—Write to the Commissioner of Patents, Washington, D. C., for the necessary instructions for making an application for a patent. These instructions will be sent free of charge. Read the instructions carefully and follow them to the letter.

* * *

(22) I am thinking of building a flat-bottomed boat large enough to carry 1,000 pounds of oil to be used on the Yukon River in Alaska. (*a*) What would be the approximate horsepower of a steam-engine for such a boat? (*b*) What size boiler would you advise me to use? W. R. M., Nantucket, Mass.

ANS.—(*a*) A 10-horsepower engine will probably give good results. (*b*) A boiler that will furnish enough steam to run the 10-horsepower engine. Its size will depend on its type, the type of engine you use, and the kind of fuel.

(23) One of my customers has 13 flat steam-coils; 8 of these consist of 26 one-inch pipes 12 feet long connected by close return bends, and the other 5 consist of 23 one-inch pipes 6 feet long similarly connected. They are built one above the other and rest upon inclined supports so that each coil pitches toward its discharge. The top coil is fed by steam at 90 pounds pressure, and each coil discharges into the one immediately below it, a continuous run of pipe being thus formed. After turning on the steam it takes two hours for water to appear at the discharge-end of the 3,100 feet of pipe composing the coils. There is *no* discharge of steam, and the flow of water is extremely sluggish. (*a*) Why does it take so long for water to appear, and why is not the discharge of water immediately followed by an escape of steam at considerable pressure? (*b*) In such an arrangement how can I estimate the loss of pressure due to the friction of the steam in the pipes? (*c*) Is it good practice to feed boilers with water from a hot-well into which a Knowles jet-condenser discharges? (*d*) Should the water-level in Caball upright boilers fluctuate rapidly, showing a variation of 8 inches in the gauge-glasses? The boilers are at a street-railway station. Is it possible that the slight quantity of oil in the hot-well is the cause of the fluctuation?

C. V. C., Boston, Mass.

ANS. (*a*) There must be an obstruction in the pipes. If they were clear, the steam would blow through them very quickly. (*b*) If we denote the absolute pressure of the steam as it enters the pipe by p_1, the pressure as it leaves the pipe by p_2, the quantity of steam that flows through the pipe in cubic feet per minute by Q, the weight of a cubic foot of steam at the pressure p_1 by w, the length of the pipe in feet by L, and the diameter of the pipe in inches by d, the loss of pressure can be found approximately by the formula

$$p_2 = p_1 - \frac{Q^2 w L}{c^2 d^5}.$$

where c depends on the diameter of the pipe and may be given the following values for pipes from ½ inch to 6 inches in diameter:

Diam. (inches)	½	1	2	3	4	5	6
Values of c	36.6	45.3	52.7	56.1	57.8	58.4	59.5

The extra loss due to the effect of bends may be included in the above formula by considering each right-angled bend as increasing the length of the pipe an amount equal to 40 times its diameter. (*c*) Yes. If the hot-well is large and the feed is taken from a point some distance below the surface of the water in the well, there should be no trouble from the little oil that enters the boilers. (*d*) It is possible that the fluctuation is due to priming caused by the action of the cylinder-oil; it is more probable, however, that the trouble is caused by the sudden changes in the demand for steam, due to sudden changes in the load on the engines. When the load is suddenly increased and more steam is used, the pressure in the boiler is reduced and steam is formed rapidly in the tubes. This steam in rising through the tubes lifts the water with it and causes the fluctuation in water-level at the gauge-glass.

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(21) (*a*) Will you inform me if the enclosed diagram shows the correct way of connecting up 3-candle-power lamps? (*b*) How can I make a blue vitriol battery? (*c*) Which is the positive and which is the negative wire or brush on a dynamo? (*d*) Which is the positive and which is the negative terminal of a cell? (*e*) How many volts does it take to make a horsepower? (*f*) What kind of a fuse cut-out shall I use to protect a 3-candle-power lamp, and (*g*) where shall I put them in the circuit? (*h*) Where can I get them? (*i*) Which is the north and which is the south pole of a battery?

T. W. C., Newmarket, N. H.

ANS.—(*a*) Your diagrams are correct. The number of cells will depend upon the voltage of the lamps you use and the number of volts each cell can furnish. A gravity-cell gives a little over one volt. (*b*) The elements of a blue vitriol or gravity-battery are copper and zinc, respectively, and are generally made as shown in the illustration. The copper element is at the bottom of the cell and is of such a form as to present a large surface. An insulated wire is connected to the copper and is brought to the top as the positive terminal of the battery. A zinc casting, or crowfoot, is hung on the rim of the jar, and is the negative element. To prepare the solution, pour in clean soft water till the zinc, or upper element, is covered, then drop in 32 ounces of blue vitriol, in small pieces. The action of the battery may be hastened by dissolving 2 or 3 ounces of white vitriol in the same weight of water, and carefully pouring it on top of the copper solution. The cell should be short-circuited a few hours before being used. (*c*) The positive (+) brush is that one from which the current is supposed to flow from the dynamo to the outside circuit, and the negative (–) brush is the one which is supposed to receive the returning current. Either can be determined by tracing to the voltmeter, by pole-finding paper, or by a magnet-needle. (*d*) The polarities of the elements of a cell have the same properties as the brushes of a dynamo and can be similarly determined. In a gravity-cell the copper is positive (+) and the zinc is negative (–). (*e*) The *volt* is not a measure of *power*, but of *pressure*. There can be no horsepower in a quantity of water unless the water is flowing. There can be no power in an electric conductor unless the current is flowing. The rate of flow of the electric current is measured in *amperes*. *Ampere* × *volt* = 1 *watt* = $\frac{1}{746}$ *horsepower*. (*f*, *g*, *h*) Cut-out No. 8,800, General Electric Co. Use ½-ampere fuse. It can be inserted near the battery. (*i*) North and south pole refer to magnetic properties.

***

(25) How should gravity-cells be connected for charging storage-cells? How many gravity-cells (plates 6″ x 8″) are required to charge four 100-ampere-hour storage-cells? E. Y. W., Bloomington, Ill.

ANS.—You will find this a very expensive operation. We can hardly see the advantage of using secondary batteries in conjunction with primary, as the current can be obtained directly from the primary—not to mention the inefficiency of the method—unless you wish to use the battery for portable services. To charge the four 100-ampere-hour cells would require 120 gravity-cells. They should be so connected up that there will be 12 rows and 10 cells in series in each row. These will be practically exhausted after one charging of the four storage-cells. The same number of Edison-Lalande cells would furnish nine or ten charges.

***

(26) (*a*) Why are fuse-wires numbered so much lower than the actual number of amperes of current necessary to blow them? For example, a fuse-wire that will blow at 24 amperes is styled an 8-ampere fuse by the manufacturers. (*b*) What is the best way to re-fuse a transformer on a live circuit? (*c*) In the circular type of rheostat, at which contact is the

greatest resistance, or must that be found out by experiment? (d) For how long a time would an alternating-current dynamo continue to generate electricity if the separate excitation were suddenly removed? (e) Of what substance is the resistance composed that is used in connection with the controlling magnets of the Thompson-Houston arc-machine? (f) What type of lightning-arresters are generally used on incandescent circuits? A SUBSCRIBER.

ANS.—(a) The ordinary carrying capacity of a fuse-wire is commonly understood to be somewhat above the capacity marked. A fuse-wire must be heated up in order to melt. Consequently, it may carry two or three times its ordinary capacity for a few seconds before it is heated sufficiently to fuse it. An 8-ampere fuse should safely carry 9 or 10 amperes for any length of time without blowing. The exact behavior of a given fuse depends on many things, such as the condition of terminals, distance between terminals, material of base, etc., but chiefly upon exposure to the influence of the air. If a fuse is enclosed so that the heat developed in the wire is carried away very slowly, the fuse will burn out at slightly above its rated capacity; but if the fuse is exposed to a cooling blast of air its maximum capacity will be much higher. (b) *No work should be done on a live high-tension alternating-current circuit without rubber gloves.* Most transformers are now made with removable fuse-blocks, which may be removed and fused and then replaced in the transformer. Sometimes the fuse cut-out is separate from the transformer and can be cut off from the main circuit with a switch. (c) Turning the handle in a clockwise direction cuts in resistance, and the reverse cuts it out. This fact can be learned by inspecting the connections, and also by observing the effect produced by turning the arm. If the rheostat is in the field-circuit of a dynamo, and the voltage of a machine is lowered by turning the handle in a clockwise direction, then as the voltage of the machine is lowered on account of the decreased field-current, it follows that more resistance has been introduced into the field-circuit by this motion. (d) For a few seconds. (e) Carbon. (f) There are nearly as many styles of lightning-arresters as there are electric manufacturing companies, but many of them are of the magnetic blow-out type. The Westinghouse Company manufacture the Wurts "non-arcing metal" lightning-arresters.

***

(27) Please give me rules for solving the following problems relating to naval architecture, viz: How to find (a) the center of gravity of a vessel, (b) its displacement, and (c) the center of gravity of its displacement when afloat.

B. W. R., Oakland, Cal.

ANS.—(a) In order to determine the center of gravity of a vessel, its form, the weight of every part, and the weight, form, and position of every portion of the load must be known. When these are all known, the center of gravity of the loaded vessel may be found in the same manner as for any system of bodies. (b) The volume of displacement, in cubic feet, may be found by dividing the total weight of the vessel and its load by the weight of one cubic foot of water, which is commonly taken at 62.5 pounds. (c) If the form of the hull is known, the submergence, or draft, can be estimated from the volume of the displacement, and, the form of the submerged portion being known, the center of gravity of the displacement may be computed in the same manner as for any irregular homogeneous body. For an elementary article explaining a method for finding the center of gravity of a plane section, see HOME STUDY MAGAZINE, July, 1897. The center of gravity of any transverse or longitudinal section of the displacement may be found by this method, and the method may be applied to finding the center of gravity of any system of bodies, by first finding the center of gravity and weight of each body.

***

(28) I have one 80-volt lamp taking 0.8 ampere, connected up as shown by the full lines in Fig. 1, *p* and *n* being the mains, *j* a junction-box, and *s z* being the branch-circuit to the lamp *l*. I wish to know how to wire up another lamp *t* in the next room, so that it will light up when the first lamp *l* burns out, or either one of the fuses *s* or *z* blow; but I do not wish the lamp *t* to burn when the lamp *l* is all right. The wires should all be lead from the junction-box *j*, which is water-tight. R. C., Eastport, Md.

ANS.—The object may be accomplished by putting an electro-magnet *m*, as shown in Fig. 1, in circuit

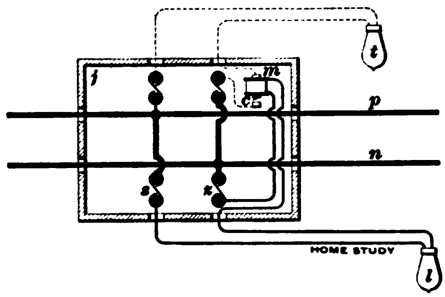

FIG. 1.

with the lamp *l*, whose behavior is to be indicated. The core *c* of the magnet *m* is in the circuit of the telltale lamp *t*. When current passes through the lamp *l*, the electro-magnet *m* is energized, the core *c* is lifted and no current passes through the lamp *t*. But if a fuse *s* or *z* should blow, or the lamp *l* should burn out, so that current ceases to pass through the lamp-circuit, then the magnet *m* would lose its lifting power and the core *c* would drop, thus completing the circuit through the lamp *t*. The magnet *m*

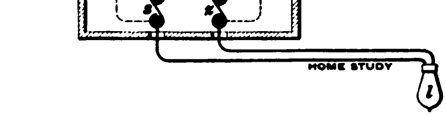

FIG. 2.

need not be in the junction-box, and a bell, operated by a battery, may be substituted for the lamp *t*. Probably a more satisfactory way would be to connect up two telltale lamps *t* and *v* as shown in Fig. 2, which will indicate the blowing of a fuse and the one which has blown, but will not indicate the burning-out of lamp *l*. The action is as follows: When the fuse *s* is all right the fuse-terminals have practically the same potential, and no appreciable amount of current flows through the lamp *t*; but if the fuse *s* blows, then the circuit is still complete through the fuse *z*, the lamp *l* and the lamp *t*, so that both lamps *t* and *l* will illuminate, but with somewhat less than one-half their normal brilliancy.

(29) I have a wire gauge, which consists of an arm swinging about the center of an iron disk, whose outer edge is spiral-shaped. The outer end of the arm is hook-shaped, and the wire is measured by being placed between the hook and the edge; then the arm is swung around until the wire is held tight. The size of the wire is then read off on one side of the disk. On the arm on the other side is found the following: "$\frac{V}{C \times D}$ = ohms per foot." (*a*) Where does this formula come from, and (*b*) how is it used?
A. E. E., Pittsburg, Pa.

Ans.—The formula, or rule, is derived from Ohm's law in a very simple manner. Ohm's law reads:

current = *voltage* ÷ *resistance.*

According to rules in arithmetic, we may multiply both sides of the equation by the same number. Multiplying by "resistance" we have:

current × *resistance* = *voltage.*

Likewise, dividing both sides by "current,"

resistance = *voltage* ÷ *current.*

Now, resistance is measured in *ohms*, and the resistance of a thousand feet, say, of a certain wire is the resistance of 1 foot multiplied by 1,000, or the ohms per foot multiplied by the distance in feet through which the current travels. The rule, then, reads:

ohms per feet × *distance in feet* = *voltage* ÷ *current.*

But we must get *distance in feet* to the other side of the equation. Then, *ohms per foot* =

voltage ÷ (*current in amperes* × *distance in feet*).

The "voltage" is the pressure exerted between the ends of the wire under consideration, and not between the mains or generator-terminals, as might be supposed. This difference of pressure between the ends of the conductor, or voltage, is commonly called the "drop." (*b*) Suppose that a dynamo runs at 120 volts, and we wish to furnish current to 110-volt lamps 500 feet from the station: how many lamps will a No. 0 B. & S. copper wire carry? The total distance traveled by the current is 1,000 feet. The drop is 10 volts. According to our gauge, or any wiring-table, the resistance per foot of No. 0 copper wire is .000098 ohms. Putting these values in the rule above found, we have

$$\frac{98 \text{ ohms per foot}}{1{,}000{,}000} = \frac{10 \text{ volts drop}}{current \times 1{,}000 \text{ feet.}}$$

Transposing,

$$current = \frac{1{,}000{,}000}{98 \text{ ohms per ft.}} \times \frac{10 \text{ volts drop}}{1{,}000 \text{ ft.}} = 102 \text{ amp.}$$

Each 110-volt lamp takes .6 ampere, nearly. So

number of lamps = 102 amperes ÷ .6 = 170.

***

(30) Can soot from bituminous coal be removed from boiler-tubes by chemical means, say by the use of zinc oxide? H. B. Y., Philadelphia, Pa.

Ans.—We know of no other way to clean tubes than by sweeping by hand or by using a steam-jet. It is very doubtful if the use of zinc oxide, or any other chemical process, would have any beneficial effect in removing the soot from the tubes.

***

(31) (*a*) Can you tell me a quick and efficient way to demagnetize the core of a telegraph-sounder? (*b*) What is the cause of the kicking of the sounder, when the circuit is closed? (*c*) Can the smoke or steam from a locomotive cause a cross or leakage between bare wires? J. H. P., New York, N. Y.

Ans.—(*a*) Iron or steel can be demagnetized by heating to a dull red and then permitting the heat to die out slowly. (*b*) If the sounder is on the local circuit, its "kicking" is a result of the local current being acted upon by the relay, and the trouble is probably on the line; but this you can easily learn by ascertaining whether the sounder responds immediately to the movement of the relay. If the trouble is on the line, whether the sounder is in the main circuit or not, the kicking may be caused by an intermittent short circuit or ground. Perhaps the vibrations of a passing locomotive swing a broken leak-wire into an electrical contact with your line. (*c*) Yes; both carbon and water are good conductors for such small currents, when deposited as a film over the insulators, pins, and arms, but their vapor will probably not affect your line.

***

(32) Can you give me a copy of the Continental Code used on Atlantic cables?
J. H. P., New York, N. Y.

Ans.—

A, · —	N, — ·
B, — · · ·	O, — — —
C, — · — ·	P, · — — ·
D, — · ·	Q, — — · —
E, ·	R, · — ·
F, · · — ·	S, · · ·
G, — — ·	T, —
H, · · · ·	U, · · —
I, · ·	V, · · · —
J, · — — —	W, · — —
K, — · —	X, — · · —
L, · — · ·	Y, — · — —
M, — —	Z, — — · ·
1, · — — — —	6, — · · · ·
2, · · — — ·	7, — — · · ·
3, · · · — —	8, — — — · ·
4, · · · · —	9, — — — — ·
5, · · · · ·	0, — — — — —

Period, · · · · · ·
Comma, · — · — · —
Interrogation, · · — — · ·
Exclamation, — — · · — —
Apostrophe, · — — — — ·
Hyphen, — · · · · —
Parenthesis, — · — — · —
Quotation, · — · · —
Paragraph, · — · — · ·
Understand, · · · — ·
Wait, · — · · ·
I don't understand, · · — — · · · · · — — · ·
Cleared out all right, · — · · — · · — ·
Erase, · · · · · · · · ·
Call signal, — · — · — · —
End of message, · — · — · — ·

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(33) Can you give me any information as to whether there is manufactured a practical automatic battery cut-out used on a gas-lighting system to protect the battery in case of a short circuit or ground?
E. B., Worcester, Mass.

Ans.—Address Weston Electric Co., New York. If the wiring is carefully put up no trouble will be experienced from grounds or short circuits. They can be easily tested for with a cheap detector galvanometer.

***

(34) (*a*) Would you kindly advise me what would be the result if the inside pole faces of a 1,040-volt alternation were to be planed off ⅛ inch? (*b*) Why does not the primary coil of a transformer short-circuit the mains? (*c*) What is the carrying capacity of a No. 00 B. & S. cotton-covered copper wire?
W. K., Tacoma, Washington.

Ans.—(*a*) The output of the machine would be considerably diminished. (*b*) An incandescent lamp is not said to short-circuit electric mains; no more does the primary coil of a transformer which is of high ohmic resistance, and also possesses a large artificial resistance due to self-induction, or counter-electromotive force, generated by the magnetism from the primary current. When the secondary circuit is open, this counter-electromotive force nearly equals the applied, or impressed electromotive force, at the primary terminals, so that the real acting

electromotive is very small and the current in the primary coil is extremely small. (*c*) About 120 amperes.

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(35) (*a*) Please state how a two-wire system can be changed into a three-wire system, and what size wire the positive and negative must be as compared with the neutral. (*b*) Please explain how to find the size of cut-out to use when the number of lamps, sizes of conductors, etc. are known. (*c*) How many cells, connected in series, will be required to run a 110-volt lamp? (*d*) How many volts are required to kill the average man? (*e*) Is it cheaper to buy current for a building using 500 lights, or to generate the current in the building and pay a man $3.00 a day to run it? (*f*) Please give directions for making a small battery of two cells. J. W. H., Boston, Mass.

ANS.—(*a*) To change a two-wire system over to a three-wire necessitates running a third wire and altering the branch-circuits to correspond. The neutral wire is generally one-half the size of the negative, or the positive. A three-wire system can be changed over to a two-wire system by connecting the two outside mains to one terminal of a dynamo and the neutral to the other terminal of the machine. (*b*) If the number of lamps is known, the current can be immediately calculated. The cut-out chosen should be amply large to carry this current, provided the design is correctly made. For example, suppose that 50 branch-circuits, of No. 14 B. & S. G. wire, extend from a 50-ampere cut-out to 50 lamps, which require in all 50 amperes. As the installation now stands, is it a proper one? No! For, suppose a short circuit occurs between two of the No. 14 wires, a large quantity of current begins to flow which the fuse is able to carry at least for a few seconds and which melts the wire and probably grounds the system. Or, suppose a short circuit occurs in one of the lamp sockets; the abnormal current flows only a few moments, but plenty long enough to melt the insulation and probably cause a short circuit and also a ground. A short circuit or ground can hardly occur without an arc, and *an electric arc is fire*. (*c*) See answer to question 518, HOME STUDY MAGAZINE for December, 1897. (*d*) Electricity kills by contracting the muscles and stopping the action of the heart; consequently it is not volts, but *amperes*, that kill. The amount of current that passes through a body depends on the volts applied, the manner of application, and the internal structure of the body. With good electrical contact and a continued application, two hundred volts direct current may kill some persons. Alternating currents apparently keep more to the surface of a body, and, consequently, higher voltages can be received with less effect, the effect decreasing as the number of alternations per second is increased. A lineman in Philadelphia recently received over one thousand volts, alternating current, for a considerable length of time. His escape from being killed is due to the fact that the current passed through his body on the opposite side to his heart, and that the alternating character of the current tended to keep the electricity near the surface of his body. By greatly increasing the number of alternations, Tesla has allowed many thousands of volts to be applied to his body without ill effect. (*e*) You will have to consult the prices of the local lighting company, and compare figures with the amount that it will cost you to generate the current. (*f*) See answers to questions 290 and 295 HOME STUDY MAGAZINE for August, 1897.

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(36) Is there any way in which I can determine the absorptive quality of brick or stone? F. H. G., Buffalo, N. Y.

ANS.—See answer to question 451, HOME STUDY MAGAZINE for November, 1897.

(37) Kindly inform me how to make a field-rheostat, and how much resistance is necessary for a 30-horsepower compound-wound dynamo, for incandescent lighting at 110 volts. D. H. P., New York, N. Y.

ANS.—Procure two slate slabs, about 10 inches square and ¾ inch thick, and prepare them for mounting on the wrought-iron base *e*, by the four ½-inch corner bolts *f*. With a common twist-drill, bore the four corner holes *a* in each slab and the wrought-iron base. Then drill nine holes nearly but not quite through the slabs. Into these holes, cement hooks, to be used to support the resistance-coils. The contacts *p* should be of brass, but if this is not convenient, stove-bolts may be used. For their reception make thirty or forty holes—the more the better. Another larger hole must now be drilled at the center for the center bolt. Two binding posts at the top of the front slate are also to be provided for. The finger *g* should be made of spring brass and wide enough to cover two contacts. About 50 feet of No. 14 B. & S. galvanized iron wire is then laid out on the floor, and, to this, wire taps of No. 16 B. & S. insulated copper wire about 14 inches long are soldered at regular intervals. There should be as many taps as contacts, one tap being soldered at each end also. The iron wire is then coiled on mandrels and afterwards slipped off and hung on the hooks previously prepared. The taps are then connected in regular order to the farther ends of the contact-bolts by a nut. Each contact-bolt will then have a nut to fasten it to the slab and another immediately following to hold the wire. A bent piece of brass is screwed under the contact, on which the lever is now shown to be resting, so that the lever can move no farther to the right. One binding post is now wired to the last contact—last, when the lever is moved around in the direction of *p*; the other binding post is connected with the center plate *f*. The present position of the finger shows all the resistance cut in. If the box is likely to be subjected to vibrations, asbestos rolls may be inserted in the coils. A cover is now put around the top, two sides, and bottom. This casing should be provided with openings for the free access of air for cooling the coils.

***

(38) (*a*) When an alternating current of electricity is passed through a transformer, is the current induced in the secondary "alternating" or "continuous"? (*b*) If alternating, is there any appliance on the market that will change an alternating current into a direct current? D. L., New York, N. Y.

ANS.—(*a*) Alternating. (*b*) A rotary transformer.

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(39) On page 84, December number of HOME STUDY FOR THE BUILDING TRADES, in the article entitled Constructive Details, it is stated that a safety factor of 6 was used in the suspension rods of the musicians' gallery, so that the value accredited to each rod would be 13,500 pounds ÷ 6 = 2,250 pounds. I cannot see why you divided by 6, and should think that in order to increase the strength of each rod six-fold you would multiply 13,500 pounds by 6, making the ultimate capacity equal 81,000 pounds. H. C. L., Starwick, N. J.

ANS.—As 13,500 pounds was the calculated *ultimate strength* of each suspension rod, it was necessary to *divide* that value by 6 (the safety factor) in order to get the load which would be safely sustained by each rod. In other words, a value of 2,250 pounds

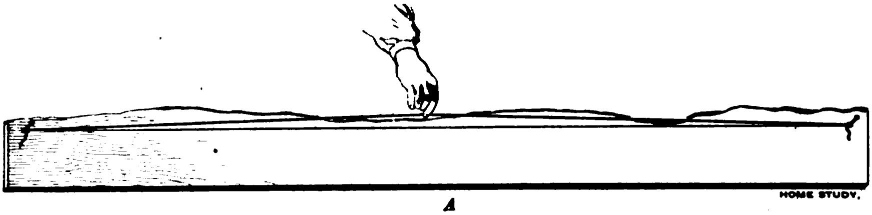
being assigned to each rod, they would each be able to carrying *six times* this amount before rupture would take place.

***

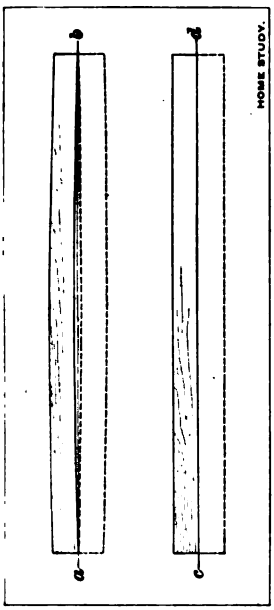
(40) (*a*) Send rule, if there is any, for jointing long timber. (*b*) How can I test a straight line on a board? (*c*) Can you give me the address of some one who carries a line of paper letters?

C. R. P., Baltimore, Md.

Ans.—(*a*) A chalk-line is generally employed for the purpose. By stretching the chalk-line tightly between the nails set to the desired line and snapping it, as shown in diagram *A*, the line so made will be as nearly true as it is possible to draw it. The line may be tested with a long straight-edge, if so desired. (*b*) To test a straight line on a board we would suggest the method shown in diagram *B*. It will be noticed at *a b* that the testing-rule employed was not a straight-edge, or, in other words, was not true. After fixing the ends to two points *a*, *b*, draw a line along the edge of the rule, then reverse the rule to take the position indicated by dotted lines, keeping the ends of the rule on the points *a* and *b*. Draw a line along this edge of the rule; then, if a line be drawn bisecting the space between these lines it will be a straight line. At *c d* is shown a straight line drawn with a true straight-edge. (*c*) Address A. Wiggers, 215 East 59th St., New York City.



A



B

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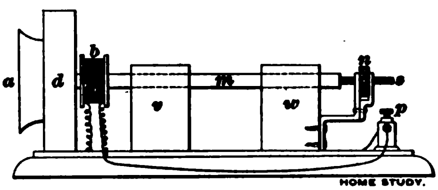
(41) I have put up a telephone line, about 200 feet long, which works well without a battery. The instrument used for a transmitter and a receiver is shown in the sketch, and consists of a bar magnet *m* mounted on the wooden blocks *v* and *w*, adjustable endwise by the nut and screw *n* and *s*. On one end is fixed the bobbin *b*. The ends of the coil are brought to two binding posts *p*. The diaphragm is contained in the box *d*, immediately in front of which is the mouthpiece *a*. The diaphragm is about one thirty-second of an inch from the end of the magnet *m*. Please explain how this works without a battery.

C. K. T., Vicksburg, Miss.

Ans.—Perhaps you have unconsciously placed a battery in circuit. If not, the instrument is evidently well made and the line resistance low. The action of the instrument used as a transmitter is as follows: The voice striking the diaphragm enclosed in the box *d* causes it to vibrate. The diaphragm, being a conductor of magnetism, causes fluctuations in the magnetic field at the end and all through the magnet *m*. These fluctuations of magnetism in the core of the bobbin *b* induce an alternating, or fluctuating, current in the coil *b*. This alternating current passes over the line to a similar instrument used as a receiver. There the action is reversed. The alternating current in the bobbin affects the magnetism, which in turn moves the diaphragm, so that it gives forth the sound.



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(42) Can you tell me of a good book on practical blacksmithing?

A. R., Richmond, Va.

Ans.—Practical Blacksmithing, in four volumes, by M. T. Richardson. This book can be obtained from The Technical Supply Co., of Scranton, Pa.

***

(43) I am a young carpenter of about four years' experience in our village. My father intends to build a new house next spring and asked me to draw the plans for it during the evenings of this coming winter. I have got along pretty well with my drawing course in The International Correspondence Schools, and I think I will be able to make a nice set of plans. I would like to ask you for some information, however, on "indirect radiation." What is meant by indirect radiation, and how does it work? Kindly give me a sketch and explain how I should show it in the plans, if need be.

X. Y., Seymour, Conn.

Ans.—"Indirect radiation" is a term used to signify that the rooms of the building are warmed by radiators which are located elsewhere than in the rooms so warmed. When steam or hot-water radiators are used to heat a building, they are known as "direct radiators" if they are located within the

rooms, because they thus heat the rooms in the most direct manner. With the indirect method, however, the heat is conveyed from the radiator to the room by means of a current of air. Indirect radiators are usually hung from the cellar-ceiling, and are enclosed in a sheet-metal casing (usually No. 20 galvanized sheet iron), or a tin-lined wooden casing, which is provided with a chamber above and one below the radiator, as shown in the figure. Cold air from the outer atmosphere enters the lower chamber through a No. 20 galvanized sheet-iron pipe *a*, called the cold-air duct. It then passes up between the sections of the radiator *b* and is heated before it enters the upper chamber *c*. Another galvanized-iron or bright tin pipe, called the hot-air pipe, or duct, joins this chamber to a register in the floor or side wall of the room to be heated, and thus permits the warm air to rise and flow into the room, as shown by the arrows. If you decide to show the location of the indirect radiators on your plans, you can easily do so by simply drawing their outlines on the cellar plan. You should also locate the boiler and chimney on the same plan. This will enable the steam-fitter to give you an accurate bid on the work.

***

(44) I consider the Answers to Inquiries in your magazine most interesting. (*a*) Kindly inform me how Spanish tiles are fastened on a roof. (*b*) How are gutters constructed? (*c*) How are *valleys* constructed? (*d*) How are *hips* constructed? (*e*) How are connections made with gable walls? (*f*) Will snow blow through a properly constructed tile roof? (*g*) How does terra-cotta of special design compare with stone in cost and durability for outside facings? (*h*) How is the stone hectograph made?

J. W. R., Hammond, Ind.

ANS.—(*a*) Spanish roofing-tiles are made in two styles. One is the plain ∽ shape with one roll concave and one convex, and having nail-holes punched about 1 inch from the top. The other has the same shape, and is known as interlocking, which term is applied because about 3 inches below the top of the tile and below the nail holes is a neck, or fillet, over which the lip of the tile above laps. Both of these tiles are manufactured by some companies with a lug or rib cast on the upper under edge by which to hang the tile to the lath. The tiles should be secured to the roof with two copper nails, as at *a*, in Fig. 1. To prepare the roof for the tiles, the following is the usual

FIG. 1.

custom: Sheathe the roof diagonally with roofing-boards well nailed at each bearing. Cover the entire roof with two-ply felt or roofing-paper, as in Fig. 1. Securely nail the tilting-fillets to the roof-boards, as at *f*, Figs. 2, 3, and 5. (*b*) The gutter at the cornice should have a galvanized-iron frame, or cradle, or, if of cast iron, the frames should be cast the shape of the gutter and set at not more than 30-inch centers and tied with a band, or rod, on the outside. The end of the frames

FIG. 2.

should extend into the wall and form an anchor. The cradle should then be filled in with cement or concrete, and covered with roofing-felt. The crown molding of 18-ounce copper should next be put in place, and the gutter proper, of the same weight metal, in lengths of 6 or 8 feet and joined by ½-inch lock-seams, thoroughly soldered and sweated together, should be placed in the cradle. The inner

edge of the gutter should be turned up against the plate to the top of the fillet, the outer edge connecting with the crown molding in a lock-seam. The lining or flashing under the tile should be nailed to the

FIG. 3.

tilting-fillet with copper nails, turned down over the fillet and connected with the inner side of the gutter by a double-locked seam. (See Fig 2.) These outer and inner seams of the gutter should not be soldered, as the expansion and contraction must be provided for. It would be well, also, if the gutter is a very long one, to pitch it both ways and use a 2-inch or 2½-inch roll lock-seam at the center, unsoldered, as an expansion-joint. (*c*) The valleys should be constructed of from 16 to 18 oz. copper in not more than 6-foot lengths, laid with a lock-seam and secured to the roof-boards by cleats of copper, soldered or sweated on the back of each length, and fastened to the roof with copper nails or with copper screws. The sides of the valley should be turned up 1 inch against the tilting-fillet, bent over its top, and nailed securely along its length. The general appearance under this treatment will be as in Fig. 3. (*d*) The hips do not require any flashings. Nail a 2″ x 5″ strip on the angle of the roof, the 5-inch side standing up, bring the tile against it, and cover with a hip-roll, as in Fig. 4. (*e*) The connection with the gable-walls should be made by first nailing the copper to the tilting-fillet and turning it *down* over the same to the

FIG. 4.

roof and then *up* against the wall at least 7 inches. From the under side of the coping turn down a 6-pound lead apron-flashing, overlapping the copper 3 inches. The vertical part of the roof-flashing should be secured to the wall by cleats not more than 18 or 20 inches apart. The lead apron will be held in place by lead plugs 1″ x ½″ at 12-inch centers. (*f*) Snow will not blow through a properly constructed tile roof for the following reasons: The roof being boarded and covered with roofing-felt, effectually stops the passage of air, and the open space under the tiles forms an air cushion, or pocket, which prevents any drift. On laths this would not be the case, as there would be no backing. A boarded and felted roof, if exposed to the air on the under side, will last as long as a lath roof if the boards are not too closely laid and if the tiles are uncemented. The tiles on the eaves, gutters, valleys, hips, and ridges should be laid in elastic cement composed of linseed-oil, whiting and resin and applied while hot. (*g*) Terra-cotta of special designs in small quantities is always more expensive than stone. If, however, the whole front is to be of terra-cotta, it will be 18 or 20 per cent. cheaper than limestone, and about 30 per cent. cheaper than brownstone or bluestone, in a building of ordinary width and 5 or 6 stories high. Terra-cotta is just as durable as stone, and possesses the advantage of being absolutely fireproof. (*h*) A hectograph consists of a gelatin pad to which impressions of

FIG. 5.

drawings made in aniline inks are transferred, and from which a large number of prints can be taken. See the answer to Question 480, in the November, 1897, number of HOME STUDY MAGAZINE. Hectographing upon stone is a similar process, in which a polished stone slab is used in lieu of a gelatin pad, and to which impressions are transferred from drawings made with lithographic and other patented inks. The formulæ for making these inks are trade secrets and unknown to us.

***

(45) Will you kindly inform me how a narrow church-spire can be prevented from swaying in the wind? The rafters of the spire seem to be as well braced as possible, but, nevertheless, the spire bends like a mast in a gale of wind.

BUILDER, Washington, D. C.

ANS.—The swaying of a spire or steeple may be prevented by suspending a heavy beam or weight from the apex of the spire. The lower the weight below the spire the greater will be the stability of the structure. The Japanese resort to this mode of treating the roofs of their towers as a precaution against earthquakes, allowing the beam to swing free so as to act as a pendulum, bringing the structure back to its perpendicular position after deflection by wind or earthquake tremor. Whether a weight so swinging actually tends to draw a deflected spire back to its perpendicularity or not is doubtful, but by attaching a weight to the apex of a spire and suspending it some distance below the spire-roof, the center of gravity will be lowered in proportion to the distance the weight may hang below the natural center of gravity of the spire.

(46) **I am thinking of using a rope for transmitting power. The driver-pulley is 28″ in diameter, the driven 36″. The shafts are 10 feet center to center, and I intend to use a tightener on the slack side of the rope. Those claiming to have had experience say that this arrangement will not work, but that the pulleys should be at least 100 feet apart. Is this so?**

J. R., Kanopolis, Kansas.

ANS.—You can, of course, use a rope drive in the way you propose; but, leaving out of consideration all question of space, it is much preferable to have the pulleys farther apart, say 30 feet at least. The general practice is to place them much farther apart than this, sometimes twice as far, depending on circumstances. This is done with a view to the increased weight of rope producing the necessary adhesion on the pulley, the sag of the rope at the same time increasing the arc of contact. (The top side, of course, is made the driving side.) The ropes should not rest on the bottom but on the sides of the grooves, the wedging action thus set up supplying the resistance to slipping that is secured in flat-belt drivers by means of great initial tension. The sides of the groove may include an angle of 45°, this being found to give good results. In a long drive, the weight of rope secures the necessary adhesion without any great initial tightening of the rope. This gives a greater life to the rope than would happen in your case. The tension pulley or tightener you propose to use has an injurious effect on the ropes, inducing a reverse bending, although this will perhaps not be so marked as in a longer drive, with, consequently, a greater sag

***

(47) (*a*) Please tell me how to level across a stream 1,500 feet wide, if the water-level is not to be depended upon. (*b*) Where should I establish a bench-mark in a city? (*c*) Where in the country? (*d*) How should I establish it in a swamp? (*e*) In framing posts how do I find the distance *A B* in the accompanying diagram? (*f*) How do I find where to cut mortise at *A* to carry roof-thighs *C A* and *A E*? (*g*) How do I find length of *C A* and *A E*?

NEW YORK READER.

ANS.—(*a*) Level across with an engineer's level having a high-power telescope, preferably with a *precise level*, such as is used in the United States Coast Survey. In order that the result may be accurate, several observations should be taken. If all observations are taken from the same side of the river, a correction for curvature and refraction should be made. For a distance of 1,500 feet, the correction for the earth's curvature and refraction under ordinary atmospheric conditions will be .046 of a foot. This correction is to be deducted from the reading of the leveling-rod. If observations are taken from both sides of the river, however, the error due to curvature and refraction may be eliminated by taking a mean of the results obtained by the observations from opposite directions. (*b*) and (*c*) On any permanent and well-defined object, such as the water-table of a public building, or upon a stone monument planted in the ground. The water-table of a stone or brick dwelling-house will do, but the more permanent and sharply defined the object is, the better. (*d*) Cut into the root of a large tree in such a manner as to make a projection shaped somewhat like an inverted letter V, the top coming to a well-defined point, and drive a tack in the top on which to hold the rod. Blaze the top of the tree so it can be found easily, and, in order to easily distinguish it from other blazed trees, mark the letters B. M on the blaze with red chalk. If the bench-mark is to be used frequently, it is a good plan to also mark its elevation on the blaze. Keep an accurate record of the position and elevation of each bench mark, with a sufficient description to positively identify it. For any system of levels, the elevation of the bench-mark from which the levels are started must be either assumed or obtained from some other system of levels. It is a common practice to assume the elevation of this primary bench-mark at such a distance above base that the elevation of every point in the system will be above base, thus avoiding negative elevations; an elevation of 100 feet is often assumed for the primary bench-mark. For locations near tide-water it is becoming a quite general practice to base the elevations of bench-marks upon the elevation of mean tide, and this practice is to be commended.

(*e*) Distance $A\,B = \dfrac{B\,F \times C\,D + D\,F \times E\,F}{D\,F}$

(*g*) $C\,A = \dfrac{D\,B}{D\,F}\sqrt{(D\,F)^2 + (C\,D - E\,F)^2}.$

$A\,E = \dfrac{B\,F}{D\,F}\sqrt{(D\,F)^2 + (C\,D - E\,F)^2}.$

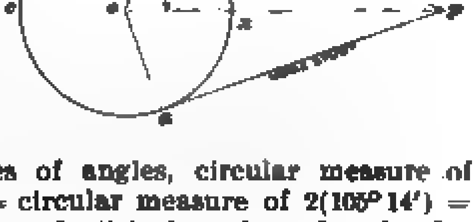
(*f*) The position of the mortise in the upright *A B* can best be found by marking off from the pieces *C A* and *A E*.

***

(48) Referring to the answer to question 241 which appeared in the July number of HOME STUDY MAGAZINE, how was the constant angle 74° 46′ 15″ obtained?

J. L. McL., San Marcos, Texas.

ANS.—Let y be the circular measure of the angle A; then, $b\,p$ = arc $a\,c\,b$ = (circumference — arc $a\,x\,b$) $= 2\,o\,b(\pi - y)$. And $\tan y = \dfrac{b\,p}{o\,b} = \dfrac{2\,o\,b(\pi - y)}{o\,b} = 2(\pi - y)$. This equation $\tan y = 2(\pi - y)$ determines the angle y, or A; this equation can only be solved by trial. As the angle y increases from o to $\frac{\pi}{2}$, $\tan y$ increases from o to infinity; and $2(\pi - y)$ decreases from 2π to π, or from 6.28318 to 3.14159. Hence, $\tan y$ must lie between 6.28318 and 3.14159. From a table of natural tangents, tan 74° 46′ = 3.67217; from a table of circular measures of angles, circular measure of 2(180° — 74° 46′) = circular measure of 2(105° 14′) = 3.67334. Since tan 74° 46′ is less than the circular measure of 2(180° — 74° 46′), this angle is too small. A second trial gives tan 74° 46′ 15″ = 3.67322, and circular measure of 2(180° — 74° 46′ 15″) = 3.67320. Therefore, A = 74° 46′ 15″.



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INCRUSTATION IN STEAM-BOILERS.*

W. H. Booth

THE PROCESS OF PRECIPITATION WITH LIME—THE HOTCHKISS BOILER-CLEANER, OR CONTINUOUS SKIMMER—THE FIELD WATER-PURIFIER FOR LOCOMOTIVES.

IT OFTEN happens that a supply of pure water is required, not only for boiler-feeding, but for drinking and culinary purposes as well. In such cases, with a carbonate water, the process of precipitation with lime may best be employed.

Fig. 1 represents the plant for such a process, which was used very successfully for 60,000 pounds of water per day.

The apparatus consists of the following parts: A tank *t* about 4′ 0″ x 3′ 0″ x 3′ 0″ deep, in which lime is dissolved upon a perforated tray, the water-supply pipe *p* directing a jet upwards against the tray-bottom. The tray is about 3′ 0″ x 2′ 0″ x 6″ deep.

From this tank a pipe *n* conveys the lime to a mixing-tray *m*, 3′ 0″ x 2′ 0″ x 6″, where it is mixed with the main supply from the pipe *s* by passing a series of obstructing plates.

From the mixer, the now mixed lime and water flows into the first division of the large settling-tank *l*. This is about 12′ 0″ x 4′ 0″ x 3′ 0″ deep, the second half being similar. The only communication between the two halves is by a small surface hole *h*, and from the second division of the large tank the final outlet is taken from the surface by the skimming-trough *f*, 4′ 0″ x 6″ x 6″ deep, and flows thence to the box *b* about 2′ 0″ x 1′ 6″ x 4′ 0″ deep. This box is loosely divided into several vertical divisions by perforated plates which serve to support several flat-woven filtering-bags, and when past this filter the purified water passes off to the well *w*. By reason of the slow motion brought about by the large cross-section of the settling-tank and the removal of the water at the surface by the hole *h* and trough *f*, only a small quantity of the finest material needs arresting at the filters. The bulk of the deposit will occur in the first settling-tank, and when the amount of water treated exceeds the settling power, the tanks would require supplementing by an additional length.

FIG. 1.

As regards the amount of lime required, 28 grains of lime will precipitate 50 grains of carbonate of lime, and will form a total

*Begun in February Number.

precipitate of 100 grains of carbonate of lime, the whole of the added lime falling as carbonate.

The chemical equation of the combination is:

$$(CaO,\ CO_2 + CO_2) + CaO = 2CaCO_3.$$

It is clear that too much lime must not be added, or the water will be rendered unpalatable from caustic lime in solution. The process does not seem difficult to manage.

In a boiler fed from such a purified source, there was merely a white powder over the whole interior, as seen by the writer, and no hard scale whatever, the white dust being evidently made up of mechanically suspended particles of carbonate carried along with the water, and not of carbonate precipitated from solution in the water.

For culinary purposes, of course, the soda process cannot be used.

When a supply only needs purifying for a boiler and not for other purposes, a much more simple arrangement is possible. On one occasion the writer found in successful operation at a limestone quarry a simple tank about 4 feet square and 3 feet deep. The feed was treated in this with soda and the lime deposited at the bottom of the tank, only clean water entering the boiler. The whole was the device of the fireman himself, as it saved him so much boiler-cleaning and blowing out.

In this connection it may be added that, though not chemically supposed to do so, common washing-soda will cause carbonate of lime to deposit. It is probable, however, that common washing-soda is an impure mixture of carbonate of soda and caustic soda, but it is clearly better, when carbonate of lime is the impurity, to use proper caustic soda.

If water of absolute purity is used in a boiler, there is no occasion whatever for using the blow-out tap. Its needless use causes waste of heat, and therefore of fuel, and it is a matter of surprise that so simple a matter as water purification should have been so neglected. A scaling-water may mean as much as two days' work for a man with a scaling-hammer, and the constant use of the hammers and chisels for scaling purposes makes the plates of a boiler as rough as a rasp and facilitates the adherence of scale. In under-fired boilers far more danger arises from scale than in flue-boilers, for in the former, no matter how easily the scale is self-detachable, it must settle on the lowest part of the boiler, and this is the plate over the furnace. In the latter type it is rare to find the furnace-sheets seriously scaled. Incrustation on these keeps freeing itself and then falls to the bottom of the boiler, where it is, comparatively speaking, cool, and there remains until cleaned out. In all boilers, then, it will certainly be economical to provide means of separating carbonates and sulphates outside the boiler, but it is useless trying to do this unless there are means to allow the water to settle after treatment. Any one may experiment in a few minutes upon the separation of lime from water, by drawing from the water-taps a glass of cold and a glass of hot water and placing in each an equal amount of water containing common washing-soda. The more rapid action with hot water proves the advantage of employing the process upon heated water.

Advantage of this fact cannot be taken where feed-water heaters of the pipe description are used, unless special provision is made for introducing the soda after passing the feed-heater in order to avoid deposition in the pipes. In such a case, however, if the feed is heated above the boiling-point the depositing vessel will have to be closed and of cylindrical form and as strong as the boiler. Plain spherical-ended cylinders of 40 inches diameter would serve for the purpose and need not be costly. The feed would enter at one end about the middle and leave from the other at the top.

Carbonate of lime, when it separates from water, is extremely light and is in minute particles. It does not sink readily, but tends to form a scum on the surface of the water, and it is therefore imperative that it should have a sufficient settling-tank, especially when the process is carried out cold and the action of separation is longer in duration.

Noting the extreme lightness of the separated particles, there are those who claim that this property may be utilized to keep a boiler clean.

There does seem good reason to suppose that scale-producers in the shape of carbonates keep at the surface for a long time, for on entering a boiler after it is blown off and cooled, mud will be found on longitudinal stays, gussets, floats, and plastered inside the dome.

Acting on the knowledge that sediment is really surface dirt in the first place, some boilers are fitted with scum-troughs, which are placed with their upper edges at the water-level, and the scum blow-out is used

several times a day when the water-level is just about one-half an inch above the edge of the trough. These are good as far as they go, but, between times of using, some of the scum settles and finds its way to the boiler-bottom.

There is, however, a continuous skimmer which requires very little waste of water in blowing out, and the action of which is based on known physical laws, which are ingeniously combined in one instrument. This is the Hotchkiss boiler-cleaner (Fig. 2).

It consists of a globular vessel *b* placed above the boiler and with an internal diaphragm, as shown. Connected with it is a funnel *c*, so placed inside the boiler as to draw in water anywhere from the lowest level to the highest. Water enters at this funnel and rises up the pipe *d* into the globe and there slowly circulates, depositing

FIG. 2.

its contained mud and passing out to the boiler-bottom by the pipe *e*, valves *h* serving to moderate the velocity of flow. The mud settles at the bottom of the globe and is blown out by the pipe *f*. The globular form is not imperative. Less frequent use of the blow-out would be secured by a larger space for deposit.

The question may be asked, How is circulation brought about? The solution of this seems to be that at every pressure there is a point at which for a certain temperature water begins to boil.

In a boiler the water which enters at *c* is not boiling but is ready to boil on the addition of another fraction of heat or the subtraction of an ounce of pressure

Now, in the pipe *d* there is less pressure than in the boiler by the head of water above water-level in the boiler, and therefore water which enters *c* as water is turned partially into steam as it ascends, and when it enters the globe some of it again goes back to water, because there is a slight cooling by radiation. The net result is that in the two pipes *e* and *d* the pipe *d* contains a greater proportion of steam than does the pipe *e* and is therefore of less density, and the downward pull in the heavier column in *e* causes circulation. The water in the boiler is, therefore, in continual circulation through *b*, entering laden with lime and leaving more or less cleared of it, and the result is simply that mud is found in *b* instead of in the boiler, and the economy which results is that due first to the ability to use the blow-off *f* only sufficiently to blow out mud without water, and secondly to the avoidance of cleaning the boiler, and finally to the reduction in repairs and saving in fuel from increased efficiency of heating surface.

Of course this continuous cleaner works best with soda. Where magnesium salts are present in the water they form a scum which will not sink. In this case the globe *b* is placed upside down and all dirt then *rises* to the blow-out *f*, which is then at the upper side of the ball. In this way the oil which has got in through a surface-condenser is discharged, and when both sinking and floating impurities are to be dealt with, the globe is placed on its side with the diaphragm vertical and a double blow-out is employed, one above for oil or magnesia froth and one below for lime, both being connected with the same blow-off tap.

Further, in reference to the use of soda to facilitate the removal of a deposit of lime, it must, not be overlooked that although sulphate of lime is almost as soluble in boiling water as in cold water, it is wholly insoluble in water heated to 300° F. Now, 300° corresponds to about 55 pounds gauge-pressure. Hence, there are few modern boilers in which all the sulphate will not deposit without soda.

Sulphate, however, makes a hard scale, and therefore it is so far an advantage to use soda so as to decompose it. Our own experience points, however, to another evil of sulphate scale. We have frequently observed, in a scale which has the appearance of sulphate, that beneath the scale the iron plate is often blackened, softened, and corroded. Two explanations of this present themselves. One is that the plate beneath, becoming heated, causes decomposition of the water or moisture next it—for the scale will be moist—and liberates hydrogen and oxygen,

and that the latter at once attacks the iron, which is reduced to magnetic or black oxide (Fe_3O_4).

Dr. Roscoe says of this oxide: "It is the oxide formed when iron is oxidized at a high temperature in the air, in oxygen, or *in aqueous vapor.*"

This has always seemed to be a sufficient explanation of the black corrosion under a tenacious scale. The second explanation is that the sulphate scale is partially decomposed with liberation of sulphuric acid, which immediately corrodes the iron, but we cannot say whether or not such a reaction is chemically possible or probable; the first certainly is. Whatever may be the cause, it is well to avoid sulphate scale by decomposition, though above 60 pounds pressure the whole of the lime will be thrown out of solution. This is again the basis of an appliance for locomotive-boilers. We refer to the Field water-purifier, shown in Fig. 3, in which the feed-pipe *b b* is doubled back and forth about six times in the upper part of the boiler-barrel. This pipe is supplied with water on either side at will, by the pipes *a*, *a*, which lead from the injectors. Being of large diameter, the pipes *b* allow sediment to deposit, and, being located in the steam-space, they are supposed to act by heating the feed up to the boiler temperature, when it will deposit all its salts. When the valve *c* is opened, steam-pressure on the openings *d*, *d* will force the contents of *b b* out past that valve, and in doing this only the pipeful of hot water need be wasted.

Salts or oil, which float, are not capable of being dealt with by this device, but for dirt, which will sink, it certainly carries conviction upon its face.

The writer does not, however, wish to be understood as advocating any appliance he may mention in this connection.

The two named are the only American devices known to him which deal with the question, and he has used them as illustrations of what has been done to solve the problem, both devices being based on principles which chemists and physicists pronounce correct, and any failure to act in practice can only be set down to some imperfection of detail or attention.

The secret of success in both-named appliances lies in keeping the deposit from settling on heat-dried plates.

A composition for decomposing lime sulphate has been advocated, namely, tribasic sodium phosphate (Na_3PO_4). This is said to act on sulphate with the formation of soluble sodium sulphate and phosphate of lime, as in the following formula:

$$2(Na_3PO_4) + 3(CaSO_4) = 3(Na_2SO_4) + Ca_3 2(PO_4),$$

this last being a loose, easily removed deposit, and the soda sulphate being soluble.

In all these chemical changes involving the leaving behind of some very soluble salt, there is still the fact that no salt is soluble forever when it is constantly added to, and in time blowing-out must be resorted to to clear away the concentrated solution of soda salts. This need not, perhaps, be frequent, but must be remembered.

On the whole, in modern boilers carrying high pressures and hot waters, we should prefer to use a little soda in the cold-water supply, never allowing the boiler to show other than an alkaline reaction on litmus paper, and endeavoring, by some mechanical means, to catch the lime and other impurities as they deposit, thus avoiding the waste of heat by blowing off large quantities of hot water and saving the continual cleaning necessary. The frequent washing-out, and with cold water, too, of locomotive-boilers must be very injurious to them if done quickly after being housed, especially if they have firebrick arches in the box, and, if left time to slowly cool, it must be a loss of time.

The washing-out of a boiler should not be an operation of frequency, but should rather, in the case of locomotives, be an accompaniment of a period of idleness for repairs. For high pressure, too, even very soluble salts become less soluble and deposit from solution, both the sulphate and carbonate of soda attaining a minimum solubility at about 90 degrees. It becomes necessary, therefore, to consider the liability of danger arising to boilers heated on the bottom through concentration of salts. In considering the respective merits of the two mechanical appliances, or similar types, the first has to be looked on as capable only of picking up "sediment" from the boiler after it is formed, though it has the advantage that, so long as the substance is floating around, it may be picked up and removed at any time.

Of appliances constructed on the principle of the second type, the advantage is in not allowing any free solid particles to get into the boiler, but the disadvantage is that any particles which do not deposit in the pipe-line can never be recovered again.

This would not matter if the barrel were the lowest part of a locomotive-boiler, for

no one ever saw hard scale on the barrel; but it does matter where the narrow fire-box water-spaces, as *e, e*, Fig. 3, become the settling-places, for this space is soon filled up and baked hard and solid.

In using soda it has been found that caustic soda is liable to damage the boiler and fittings, and soda-ash is often substituted, and seems to be efficient even with lime carbonate, and, in a case recently brought to our notice, was employed with a mechanical boiler-cleaner of the type mentioned to effect precipitation. In this case all solid matter was found to be removed, boilers that were not opened for a year being found quite clean, though using water from a chalk-well.

The writer is convinced that there is no necessity any longer for the formation of scale in any steam-boiler. It is claimed that even salt crystals will be removed from a marine boiler by a cleaner of the circulating type; to this the writer cannot either assent or dissent, in the absence of personal knowledge, but it seems probable, and, if so, must add immensely to the economy of coal at sea by avoiding the very heavy blowing-out now necessary when surface-condensers are not used, and several hundred pounds of salt are daily taken into a boiler.

About 50 pounds of salt are thus introduced for each square foot of grate surface every 10 hours.

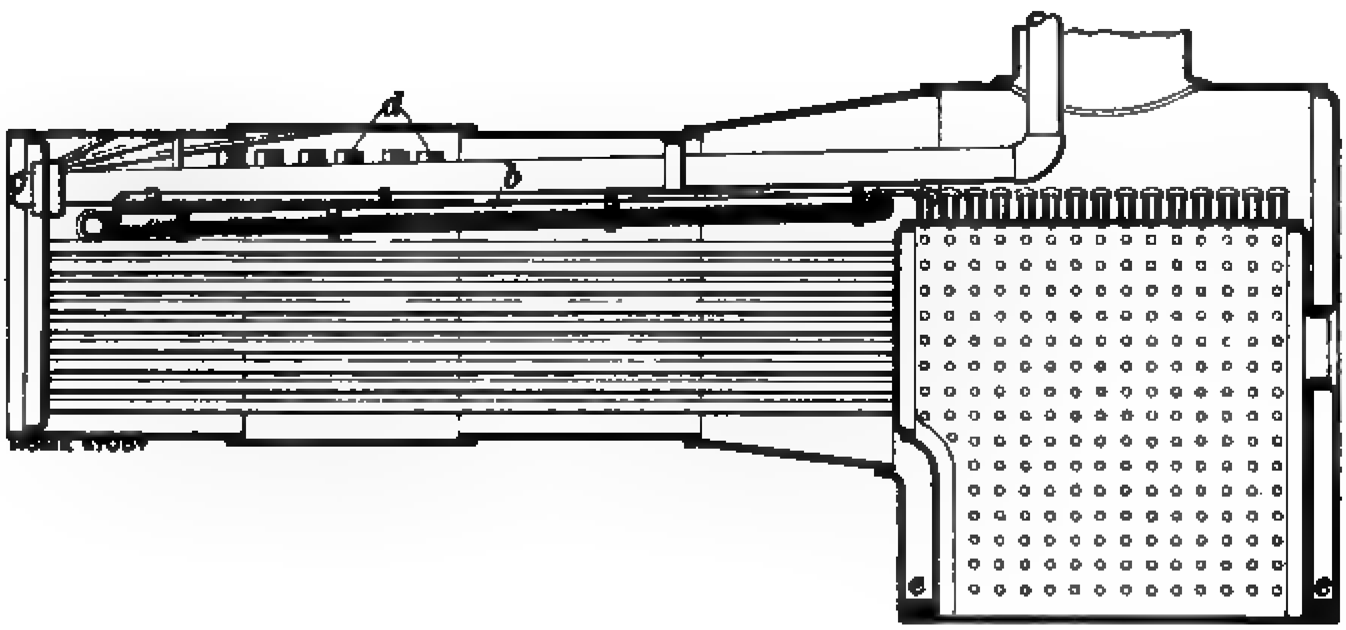


Fig. 3.

ALTERNATING-CURRENT TRANSFORMER.

Alexander Stratton.

ADVANTAGES OF THE ALTERNATING CURRENT FOR LONG-DISTANCE TRANSMISSION—LOSS ON LINE—VOLTAGE AND SIZE OF WIRE—PRINCIPLE OF THE TRANSFORMER.

THE alternating current has attained its present prominence because of its peculiar adaptability for transmission over considerable distances. In order that power may be transmitted profitably over long distances by electricity, two principal conditions must be fulfilled:

First—The line which transmits the power must do so with comparatively small loss.

Second—The cost of the line itself must not be excessive.

If, in transmitting the power, 50% of the original amount is lost in the conducting-wires, it is easy to see that the available power would have to be sold at prohibitive prices in order to bring any profit. The loss of power in the transmitting-line is due to the resistance which the conducting-wires offer to the flow of the electric current. To force the necessary current through this resistance requires a certain electrical pressure, which pressure is, of course, lost, and is not available for power at the far end of the line. The case is similar to that of pumping water through a long pipe-line. If we start with a pressure of 50 pounds at the pump, and the pipe is too small for the easy progress of the water, the pressure at the further end may be reduced to, say, 25 pounds, the other 25 pounds having been used up in overcoming the resistance offered to the flow of the water.

In order to reduce this resistance we could put in a larger pipe. So, in transmitting the electric current, we can reduce the loss of power in the line by increasing the size of the conducting-wires.

This brings us to the second consideration: that, in order to make the plant a profitable one, the line itself must not be too expensive; in trying to reduce the loss in the line, a point will soon be reached where the conductors will become so heavy that the net receipts from the sale of power will not equal the interest on the money invested in erecting the line and the cost for repairing the same.

In using high electrical pressures, however, we find a solution for both problems. Electrical power is equal to electrical pressure multiplied by electric current; hence, for a given amount of power, the larger the electrical pressure the smaller will be the current; so that, by using a high electrical pressure, it is possible to transmit the required power through small wires with comparatively little loss.

An example will make this plain. Our fundamental rules are simple: I. Electrical power in *watts* = electrical pressure in *volts* multiplied by current in *amperes*. II. Pressure in *volts* lost on the line = current in *amperes* multiplied by resistance to current flow in *ohms*.

These rules can be written as formulas, thus:

Let W = electrical power in watts;
E = pressure in volts;
C = current in amperes;
R = resistance, in ohms, to current flow.

Rule I becomes

$$W = E \times C, \qquad (1)$$

from which may be derived the formula

$$C = \frac{W}{E}. \qquad (2)$$

Rule II becomes

Lost pressure in volts $= C \times R$. (3)

Suppose it is desired to transmit 75,000 watts (about 100 H. P.) over a line which offers a total resistance to the flow of current of 1 ohm; and let the electrical pressure at the distributing-end be 500 volts. Using formula (2) the current $C = \frac{W}{E} = \frac{75,000}{500} =$ 150 amperes, and the pressure lost in the line will be $C \times R = 150 \times 1 = 150$ volts; so that in order to obtain 150 amperes at a pressure of 500 volts, the generator must give a pressure of 650 volts, 150 volts being used up on the line; 150 is about 23% of 650, so that the loss on the line is equal to 23% of the total amount supplied by the generator.

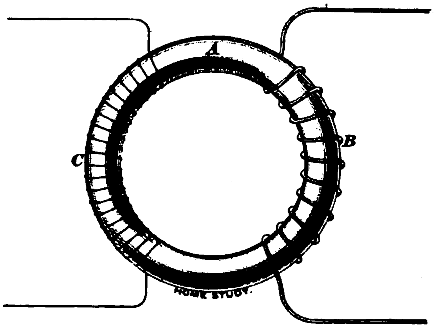
If, however, the pressure is made 1,000 volts, the necessary current $C = \frac{75,000}{1,000} =$

75 amperes, or only one-half what it was before; we can, accordingly, use a wire having one-half the area, and, hence, one-half the weight of that first considered.

The resistance to the flow of current will now be doubled, becoming 2 ohms, because the conductor has only one-half the area; and the volts lost will be $C \times R = 75 \times 2 = 150$, making the volts at the generating-end $1,000 + 150 = 1,150$. But 150 volts is only 13% of 1,150 volts, so that by doubling the voltage the weight of copper has been reduced to one-half its former amount, and the loss is only about one-half as much. If we agree to allow the same percentage of loss as in the first case, the weight of wire will be reduced to nearly one-quarter of that necessary for transmitting the power at 500 volts.

This shows conclusively that for commercial transmission of power we must use high voltage.

But here a difficulty arises. High voltages



are dangerous to life, and high-voltage generators are peculiarly liable to give trouble. If we could only use a generator of comparatively low voltage, and transform this voltage up to the desired value on the line, and again transform to a low voltage at the other end, we would have safe voltages both at the power station and at the point of distribution, and still derive all the benefits of transmission with high voltages on the transmitting-line.

Here is where the alternating current finds its logical field, all the advantages claimed for the alternating current in transmission of power resolving themselves into one, namely, that the alternating current can be easily and economically transformed from low pressure to high pressure and vice versa.

This transformation is accomplished by means of the alternating-current transformer.

Before considering the transformer, let us clearly get before our minds the fact that its purpose is simply to *transform pressures*, and that it can in no way *increase the power* supplied to the circuit. If a generator supplies 5 horsepower to a transformer, we can never obtain more than 5 horsepower after the pressure has been transformed; indeed, we can never obtain quite as much as 5 horsepower, because transformation is always accompanied by losses in the transforming mechanism; so that the "output" of a transformer must always be less than the "input."

If the transformer is supplied with large current at low pressure, and the pressure is transformed up, the current obtainable will be correspondingly less.

As regards the actual construction of the transformer, there have been many different forms, the original one being well known under the names "medical coil" and "induction-coil." But these forms have all settled down to practically one design, consisting of a laminated iron core forming a closed magnetic circuit (a magnetic circuit without air gaps) and surrounded by two sets of coils—a "primary" which is connected to the generator, and a "secondary" for transforming the voltage of the primary up or down according to the design. These coils are not connected to each other, and are also insulated from the iron core. In the figure such a transformer is illustrated; *A* is the laminated iron core forming a complete ring; *B* and *C* are the two coils. If *C* is connected to an alternating-current dynamo, it becomes the primary, and *B* is then the secondary. The coils are interchangeable, and either may be made the primary, depending on whether we wish to transform up or down. In practice the primary coil is usually wound directly over the secondary to insure good regulation.

The action of a transformer can best be understood from the standpoint of a dynamo. We know that electromotive force, or electrical pressure, is generated when coils of wire properly connected are moved so as to "cut" magnetic lines of force. This is accomplished in the dynamo by an armature on which coils of wire are wound and which revolves between the poles of the field-magnet, thus causing the coils to cut the lines of force. But the same effect would be produced if the armature is held still and the lines of force are moved so as to cut the coils in the same manner. In fact certain types of alternating-current dynamos

are built on this principle. Now, a transformer is, after all, only a special type of alternating-current dynamo, in which the iron core is the field-magnet, the primary coil the field-magnet winding, and the secondary coil the armature-winding. Instead of the armature being moved so as to cut the lines of force in the magnet, the lines of force themselves are made to move by the action of the primary winding, so as to cut the secondary winding and thus generate the required voltage. When the primary winding is connected to an alternating-current dynamo, the alternating current which flows through it causes the iron ring to become an alternating magnet, that is, lines of force surge to and fro in the iron core, thus "cutting" the secondary winding and generating an electromotive force in it; the ratio between the primary voltage and secondary voltage is the same as the ratio of the turns. Thus, if we want to transform a primary voltage of 1,000 to a secondary voltage of 5,000, the secondary winding must have five times as many turns as the primary.

Since lines of force alternate in the iron core, it must be laminated, just as the armature of a dynamo is laminated, otherwise wasteful currents will flow in the core.

There remains one action of the transformer yet to be considered, and that is its inherent regulating properties. It is evident that, if the primary winding takes the same amount of energy whether the secondary winding is delivering power or not, the use of the transformer for power transmission would be out of the question, because the generator would be compelled to supply full power when none was being used at the other end of the line, and, hence, none being paid for. The transformer, however, acts, in this respect, very much like an ordinary direct-current motor. When such a motor is running without any load, the conductors on its armature generate an electromotive force opposed to that of the circuit to which it is connected; and this opposing electromotive force is of such a value that only enough current is allowed to pass through the armature to keep the motor running at its normal speed against friction and other losses. As soon as a load is put on the motor, the armature slows down, so that the counter electromotive force is reduced just enough to let the additional current necessary to do the work flow through the armature.

An action very similar to this takes place in the transformer. When the secondary winding is not supplying energy to the line, the alternating magnetism in the iron core causes a reactionary voltage in the primary winding, whose effect is to allow only enough energy to be supplied to the primary to overcome the losses which occur in the iron of the magnetic circuit. When the secondary supplies power to the line, this reactionary effect is lessened in just the right proportion to allow the primary to take the necessary increase in energy from the generator.

Of course, a direct current could not be transformed by such a device as has been described, because, although a direct current would magnetize the iron core, this magnetism would *remain constant*, because the primary current is constant, and, hence, no voltage would be generated in the secondary winding.

MEASURING WATER-PRESSURE.

WATER-PRESSURE is measured in pounds per square inch above that of the atmosphere by means of instruments called pressure gauges.

Ordinary steam-pressure gauges, such as those used on steam-boilers, are commonly employed for determining pressures less than 100 pounds per square inch. For higher pressures, however, specially made hydraulic gauges should be used.

When water gauges are subjected to shocks due to water-hammer in the pipes, the mechanical parts soon become deranged, or the elliptical tubes become permanently swelled by the heavy and almost instantaneous blows; the gauges then become useless as pressure-indicators. To prevent damage to a gauge from such a cause, it is customary to place a large air-chamber on the line of pipe and near the gauge. The air-chamber acts as a cushion and relieves the gauges of any sharp blows.

THE GAS-ENGINE.

E. W. Roberts.

GAS-ENGINE IGNITERS—FLAME-IGNITION—HOT-TUBE IGNITERS—ELECTRICAL METHODS—THE TIMING-VALVE—EXHAUST MUFFLERS—A MECHANICAL OILER.

PART IV.

THE efficient working of a gas-engine depends no less upon the proper proportioning of the compression-space to the volume of the cylinder than upon the care with which its accessory parts are designed and constructed. The chief accessory to any gas-engine is the device for igniting the charge. Of this mechanism two things are required: first, that it shall fire its charge with unceasing regularity; second, that it shall cause ignition to take place at the proper point in the stroke. Nothing is more annoying to the gas-engine user than a bad or indifferent igniter. Failure to ignite the charge for several revolutions in succession will cause the stoppage of the engine, and a continued recurrence of badly-timed ignitions will frequently accomplish the same result.

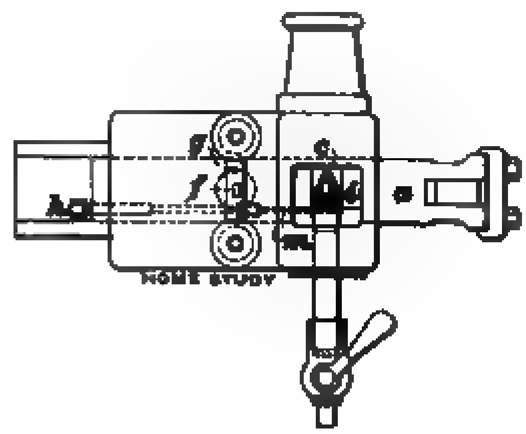
There are three distinct methods of ignition:

I. Ignition by direct contact of the charge with a gas-flame.

II. Ignition by contact with a heated surface.

III. Ignition by means of an electric spark.

An example of the first method has been given and explained in Part II of this series on the gas-engine in connection with the Otto engine. The flame-igniter used on the Clerk engine is illustrated here at *C*, Fig. 1. Views *A* and *B* are sectional plans of the slide valve *a* and the end of the cylinder, showing the location of the explosion-port *P*, the latter opening directly into the compression-space. A portion of the charge passes from the motor-cylinder through the small hole *g* to a channel in the face of the valve *a*, from which it passes through the hole *m* to the grating *e*. The Bunsen flame *i* hugs closely to the back of the valve and the face of the grating, so that the mixture is ignited through port *c* before it has time to fill the compartment *b*, and an annoying explosion is avoided.



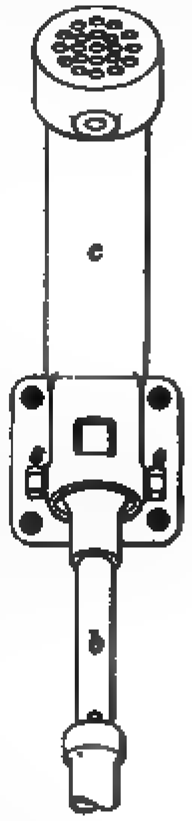
A *B* *C*

FIG. 1.

The grating prevents the flame from passing back to the motor-cylinder through *m* and *g*, so that it flows out through *d* and *k* to the atmosphere. The slide now moves from the position shown at *A* to the position shown at *B*, the port *c* being closed first and port *d* closing immediately after. Before the flame can be extinguished by the accumulation of burned gases in the space *b*, port *d* is opened to *f* and to the explosion-port *P*. The direct contact of the flame ignites the charge at the end of *P*, the flame immediately filling the compression-space. At *h* is a long pin which is screwed into the end of the slide and can be used to control the flow of the mixed gases from *g* to the passage *m* shown in *C*, Fig. 1.

As many as 300 ignitions per minute can be obtained with this apparatus, a much greater number than it was possible to get

with the Otto flame-igniter. Since the Clerk engine has twice as many explosions for the same number of revolutions, it was necessary to provide a quicker-acting device than that previously used on the Otto. Many variations of the flame method have been employed on the earlier makes of gas-engines, some of them very ingenious, but a great number complicated and cumbersome.



It was but a step from the flame method to hot-tube ignition, which is that form of Method II now in more general use. A hot-tube igniter, with timing-valve, is shown in Fig. 2. The tube *t* is made of platinum, nickel, steel, porcelain, or wrought iron. By means of the Bunsen flame *f* the tube is kept at a temperature just high enough to ignite the charge. A somewhat careful regulation of this temperature is required, since, should the tube get too hot, the strength is impaired and the force of the explosion may cause it to burst. The regulation of the temperature is effected by adjusting the height of the burner *b* or the height of the flame, preferably by the former method. The hottest part of the flame being close to the tip, the burner should be raised to lower temperature of the tube, and lowered to raise the temperature of the tube. Communication with the compression-space is obtained by way of the opening in the timing-valve *a*. This valve opens at just the proper time for ignition, hence the term "timing" valve. At *g* is a small pet-cock, used for clearing the tube of any accumulation of soot. When the pet-cock is opened, one or two explosions will soon blow all the soot from the tube.

Fig. 2.

Fig. 3 shows an arrangement for hot-tube ignition *without* a timing-valve. The tube *t* is heated in the usual manner by a flame from the Bunsen burner *b*. The chimney *c*, together with the burner, can be adjusted by moving them along the rod *r*. This serves the purpose of adjusting the position of the incandescent portion of the tube at various distances from the cylinder *A*. When the engine exhausts, the contents of the tube, consisting of uninflammable gases, rush out until the pressure within the tube is reduced to that of the atmosphere. On the compression of the new charge, this non-inflammable mixture is driven back up the tube, followed by the fresh, unburned gases. As soon as the combustible gas reaches the incandescent portion of the tube, it is ignited, and the explosion drives the flame out through the ignition-port *p* to the compression-space *A*, where it fills the entire space. The set-screw *y* holds the chimney on the rod *r*. The burner is pivoted on the two screws *s*, so as to permit the flame to be adjusted about the tube. At *g* is the usual pet-cock for clearing the tube of soot.

Fig. 3.

In hot-tube igniters of this kind, the adjustment of the flame is a matter requiring skill and experience, and can only be accomplished by trial. A general rule is: move the burner up the rod *r* if the charge fires too soon, or down the rod if ignition takes place too late. Some makes of engines

have open-tube igniters without adjustable burners. The makers of such engines adjust the burner by trial before the engine leaves the factory. Other varieties of the second method use no external flame. In these the exploding charge heats a metal surface to incandescence, and the temperature of the surface remains at a point sufficiently high to ignite the succeeding charge. A suitable form of burner is used to heat the metal surface before starting the engine, after which it needs no further attention.

This method of ignition has found great favor among the oil-engine manufacturers. The writer cannot, however, recall an instance of its use in modern gas-engine practice For this reason, a detailed description of this form of igniter would be out of place here.

Electrical methods are slowly but surely replacing all others. The reasons for this are obvious. With the exception of the heated-surface method just described, where sufficient heat is stored by the explosion of one charge to ignite the next, all other igniters are more or less wasteful of gas. Of course, the proportion of this waste to the amount of gas used in the engine decreases as the volume in the cylinder grows larger, yet it always remains an important item in the economy of the gas-engine. Another advantage of the electrical method is that the charge can be fired at *exactly* the right time. No other method is absolutely reliable in this respect, although flame- or tube-igniters, having timing-valves, are usually quite reliable under constant conditions of pressures and mixtures before ignition. No preliminary experimenting is required to determine the firing-point, since the spark, being made in the compression-space, fires the mixture at once, and no allowance has to be made for the propagation of a flame through a passage. Again, the time of ignition depends but little, if at all, on the condition of the mixture, when fired by a spark in the body of the gas.

An electric igniter is shown in Fig. 4. The plug P is screwed into the head of the cylinder and extends some distance into the compression-space. Two porcelain insulators i, i extend entirely through the plug, while through the center of each insulator runs a copper conductor c, c terminating, inside the cylinder, in platinum points. From c, c the wires e, e make a metallic connection with the secondary terminals s, s of the induction-coil I. Current is furnished by the primary battery $B\,B\,B$, from which the current flows to the binding post p through the primary of the coil to p', thence to the spring contact piece x through the knob k to the contact piece x' and back to the battery. The knob k rotates with the shaft S, to which it is attached. in the direction of the arrow. It thus completes the primary circuit once in each revolution of the shaft. Two sparks in succession are formed between the terminals of the conductors c, c, one when the primary circuit is completed by k and one when it is broken. The position of the knob on the shaft determines the exact movement when the circuit is completed and the first spark is formed, since this spark is the one which ignites the charge. On a two-cycle engine the knob may be attached to the crank-shaft, while on a four-cycle engine it should be attached to the valve-shaft.

FIG. 4.

In Fig. 5 the principles of the Sintz electric igniter are shown. In this device the current passes from the batteries through a coil of copper wire wound on an iron core; a *spark-coil*, as it is called by electrical men. The effect of the spark-coil is to produce an intense electric pressure in the circuit just at the instant the circuit is broken. This high pressure causes a spark to be formed across the gap.

The igniter is constructed as follows: A hollow plug o is screwed into the cylinder-head, a portion of which is shown in section

at *C*. The bushing *b*, somewhat smaller than the bore in *o*, is passed through the plug from the lower end and held in place by the nut *n* and the washer *w*. The plug is insulated from *b* and *w* by the mica insulation *m*, so that no current can pass from *b* to the engine. The threaded rod *r* is screwed completely through the center of the bushing *b*, being locked in position by the nut *k*. The end of one wire conductor *c* is passed through a hole near the top of *r* and made fast by means of the wing nut *W*. At the lower end of *r* is a contact piece *Z* attached to a spindle *z*, the latter passing through the wall of the cylinder.

If the cylinder were to be turned around, the other end of *z* would be brought into view, showing the mechanism at the right of the figure. The disk *f* is free to turn about the spindle *z* in either direction, as shown by the double-pointed arrow. A portion of *f* is removed in order to show the spiral spring *x*, which is just like the mainspring of a clock. The outer end of *x* is attached to *f* and the inner end to the spindle *z*, so that when there is no resistance to the turning of *z*, it will move with the disk. If, however, the motion of *z* is checked in any way, as by the piece *Z* coming in contact with *r*, the disk will only wind the spring. Directly behind *f* is another and similar revolving disk, to which is attached the arm *e* and the stop *y*. The

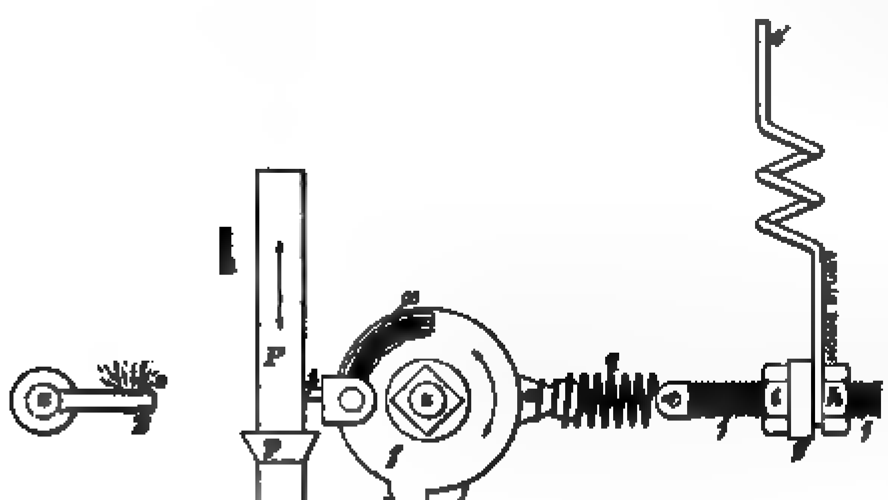


Fig. 6.

arm *e* is held in a horizontal position by the spring *q*, the latter being held taut by the screw *j*, which is clamped in place by means of the nuts *h* and *i*. The piece shown at *g* is the end of an arm coming straight out from the engine. It can be seen in Fig. 4, of "The Gas-Engine," Part III, in Home Study Magazine, for February, 1898. The

motion of the disk simply winds the spring *x* until the pawl *t* slips from the collar *p*. *Z* is pressed tightly against *r* by the tension of the spring *x*, thus insuring good electrical contact. When *t* slips off the collar, the disk *f* flies around and the stop *y′* strikes *y*, carrying the rear disk with it a short distance and being finally brought to rest by the spring *q*. As *f* flies back, the contact *Z* leaves *r*, thus opening the circuit and forming the spark shown at *s*, a veritable *splash* of flame. The action of the spring *x* is so rapid that there is no appreciable time between the moment when *t* slips from the collar and when the flash occurs at the break. The rod *P* is adjustable, in the direction of its length, so that the time of ignition can be arranged to take place early or late, according to the speed of the engine and the rapidity of inflammation of the charge. When properly adjusted this mechanism seldom, if ever, misses fire. The reader will notice a similar

device on the Otto engine, Fig. 5, Part II, of this series.

A simple igniter is illustrated in Fig. 6. The plug *p* screwed in the wall of the cylinder carries a helical spring *s* on its inner end, the spring and its connections being insulated from the engine. The free end of *s* forms a tongue, or contact piece *t*. Attached to the piston-head is the stirrup-ended rod *r*. As the piston nears the top of its stroke the cross-bar of the stirrup strikes the tongue, carrying it along until it slips off the bar, making a sudden break and producing a spark. Of course, the bar will strike the tongue on the down stroke, producing a second spark, which is evidently useless unless the first spark fails to fire the charge. This device is open to several objections. A "wiper break" is not reliable without a powerful battery. Also, the spring *s* is exposed to the intense heat of the burning gas and will soon lose its temper, and, consequently, its elasticity.

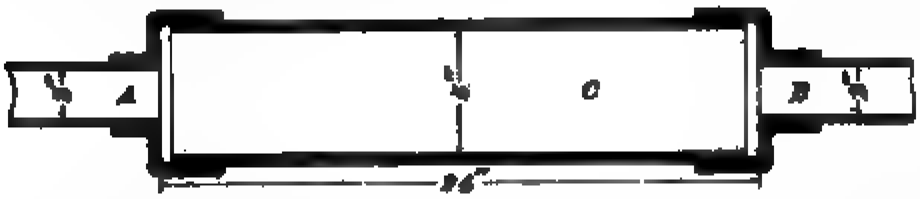


Fig. 7.

The high terminal pressure usual in a gas-engine is accountable for the noisy exhaust. In many places this noise is undesirable, and to reduce it to a minimum the gas-engine builder supplies a device called a *muffler*. The escaping gases are usually led into a chamber where they will strike a number of partitions or an air-cushion.

A much-used form of muffler is shown in Fig. 7. The proportion of the muffler-chamber to the exhaust-pipe is readily seen by referring to the figures. Supposing the exhaust gases come from the engine through *A*; on entering *C* they expand and part of the gas escapes at once through *B*, but the pressure is reduced by expanding in *C* and the gases pass out through *B* much more slowly, and with less noise, than if the chamber *C* had not been present.

Many other contrivances have been devised for this purpose. In some of these the chamber consists of a rectangular box instead of the cylindrical form shown in Fig. 7. In others the chamber is filled with twigs, or divided into a number of compartments by partitions. Some mufflers are made with a cap perforated with a number of small holes, in the place of the pipe *B*, Fig. 7. These last three arrangements aid in reducing the sound by putting more resistance in the path of the escaping gases, the object of all exhaust-mufflers being to reduce the velocity of escape. Probably the simplest of all mufflers is a length of rubber hose attached to the exhaust-pipe, the flexible walls of the hose acting as a cushion.

Fig. 8 is a vertical section of the mechanical oiler so well known to users of the Otto engine and shown at *O*, Fig. 5, Part II. The shaft *c* is rotated by means of a belt connecting the pulley *a* to the valve-shaft. The small crank *g*, being fast to shaft *c*, revolves with it. On the outer end of *g* is a

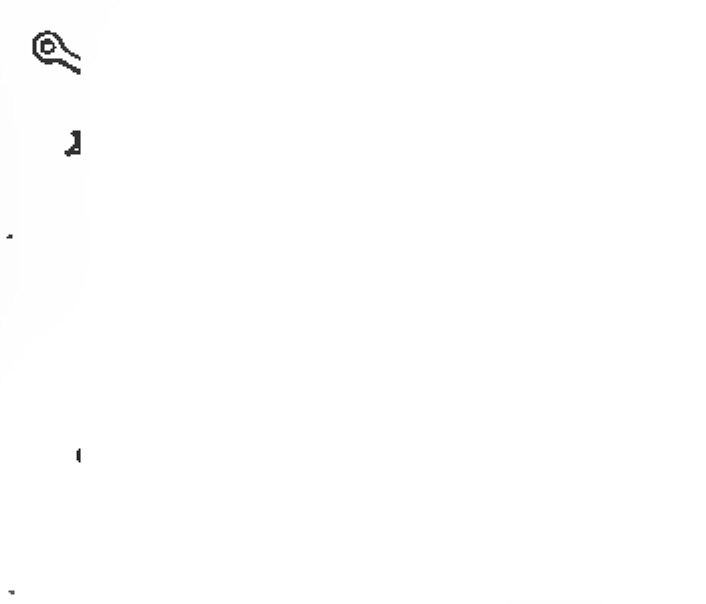


Fig. 8.

small wire *d*, which is left free to swing about the end of the crank. At each revolution this dips into the oil at the bottom of the cup, and on the upper part of the revolution the wire is dragged across the pin *e* as shown at *X*, wiping off the oil, which drops into the basin *f* and flows down the pipe *b* to the part to be lubricated. Many other oilers are in use, but the simplicity and convenience of this type still keep it popular with gas-engine builders.

INDIRECT STEAM-HEATING.

Thomas N. Thomson.

HOW AIR FLOWS THROUGH THE SYSTEM — AIR, WHETHER HOT OR COLD, WILL ALWAYS FLOW TOWARDS PLACES OF LOW PRESSURE.

INDIRECT steam-heating is a method of warming buildings by steam, in which the heating surfaces, or *indirect radiators* as we call them, are located outside of the rooms to be warmed, communication being had between the rooms and their respective radiators by means of large air-conduits, commonly called *hot-air ducts*.

By using this system of warming buildings, the radiators are not open to view, as are the direct radiators (those radiators which are placed within the rooms to be warmed and which are not in any way connected with the ventilation of the rooms), but are entirely concealed; they are usually located in the cellars or basements of the buildings, and are completely encased by boxing of some material which is a non-conductor of heat.

It is customary to "box in" each indirect radiator separately, using the radiator for a partition, as it were, to divide the box into two compartments or chambers—an upper and a lower one. The upper chamber communicates with the room to be warmed by means of the hot-air duct, and the lower chamber communicates with the outer atmosphere by means of another conduit, commonly called the *cold-air duct*. Since the sections which constitute the entire radiator are spaced apart, the air in the box, being heated by the radiator, will rise through the hot-air duct and flow into the room, cold air from the outer atmosphere replacing it. It will thus be seen that, by the indirect method of warming buildings, we may have ventilation as well as heat.

Before we proceed too far with the principles of warming buildings by indirect radiators, let us investigate the movement of air by the force of gravity, because air is the medium which conveys the heat from the indirect radiators to the rooms to be warmed, and the success of an indirect heating apparatus depends to a great extent upon the flow of the air through the system.

Let us take two pipes of equal length and sectional area, as shown at *a* and *b* in Fig. 1, and join them at their lower ends by two right-angled elbows. We place these tubes, which are now fitted together in the form of a U, in a still atmosphere, and leave their ends open and level with one another. We also attach two thermometers *c* and *d* to the tubes in such a manner that their bulbs will

FIG. 1.

be inside, that we may detect the temperature of the air in each tube. At the top and bottom of *b*, we attach water gauges *f* and *e* in such a manner that changes of pressure in *b* can be detected by a difference between the levels of the water in the columns of the gauges.

When the density of air in one tube is precisely equal to that in the other tube,

their temperatures not being considered, the air will be in perfect equilibrium; that is, there will be no flow of air through the tubes.

If, however, the mean density of the air in one tube is greater than that of the air in the other, the more dense air, being heavier, will fall, and the less dense air, being lighter, will rise and flow to the atmosphere. A difference in density causes a difference in pressure, and the difference in pressure is the force which causes the air to flow through the tubes. This we will illustrate by placing an air-tight cap *g* over the mouth of *b* and applying heat to the base of this tube, as shown at *h*. As the air in *b* is heated, it expands about $\frac{1}{491}$ of its volume at 32° with each degree rise in temperature, and, the pressure remaining practically unchanged, this amount of expansion passes into the tube *a*, thereby causing a loss in weight to the column of air in *b*. Continuing the application of heat to the air in *b*, and observing the two water gauges, we notice that the water-lines in *e* remain perfectly level, while there will be a slight difference between the levels of the water-lines in *f*; this difference would be more pronounced if a differential gauge were used. This proves to us that the pressure at the base of the column of hot air in *b* is precisely equal to that of the atmosphere, while that at the top of the same column is greater than that of the atmosphere at the same level.

This may be accounted for thus: The pressure at the base of *a* is due to the weight of the atmosphere above the tubes plus the weight of the air in the tube *h*; but, as the pressure at the base of *b* is the same as that at the base of *a*, there being direct communication between these points, and as the pressure of the column of hot air in *b* due to its weight is less than that of *a*, it is clear that a certain force reacting upon the under side of the cap on top of *b* is required to compensate for this loss of pressure due to loss of weight of the air in *b*. In other words, suppose the air in *a* to be 1 pound heavier than that in *b*; then, a total pressure of 1 pound is required upon the top of the hot-air column to prevent it from being forced upwards by the greater pressure of the air in *a*, due to its greater weight.

Suppose that we now remove the cap *g*; the hot air will instantly flow from the area of higher pressure to the area of lower pressure, i. e., from *b* to the atmosphere, and will continue to flow until the two columns reach the same temperature and balance each other.

If, however, we remove the cap from *b* and place it tightly upon *a* before the hot air has time to escape, we shall observe different conditions of pressure; the gauge *e* will indicate a pressure at the base of *b* less than that of the atmosphere, while *f* will indicate no difference of pressure between the outside and inside of the tube. This can be easily accounted for when we consider that the decreased pressure at the base of *b* is due to the loss in weight of the hot air by expansion.

In order to thoroughly understand the principles of heating and ventilating by the indirect radiator system, let us refer to Fig. 2. Two boxes *A* and *B* are joined together by

FIG. 2.

sheet-metal pipes *a*, *b*, and *c*, as shown. In *A* is placed an indirect radiator *d*, supplied with steam by the pipe *e*, any water of condensation being allowed to drain into the pail through the valve *g*.

Another sheet-metal pipe *k*, having a damper *g* attached, and which is shown open in the figure, joins *B*, its upper end being open to the atmosphere a few feet above *B*. The damper *h* in the pipe *b* is closed and the damper *i* in *c* is open.

While the boxes and pipes all have a

temperature equal to that of the surrounding atmosphere, there will be no circulation of air through the apparatus, because there is no difference in the density of the air at any part. Suppose that we now open the steam-supply valve *f* and the condensation-valve *g*, thus allowing steam to flow through the radiator and heat it; we shall find that the air within the box *A* will absorb heat from the radiator *d*, and become rarefied, that is, made less dense than the surrounding atmosphere. This hot air will flow up *a* into *B* and finally pass through *k* to the outer atmosphere, as shown by the arrows, cold air at the same time flowing in through *c* to take its place. In this way we move cold air from the box *B*, and fill it with hot air from *A*; we not only heat the space *B*, but ventilate it also. If we close *g*, thus making *B* an air-tight box, circulation of the air will cease. Hot air in *A* will not flow into *B* because there is no means of escape for the air.

Fig. 3.

The box *B* by radiating its heat to the atmosphere will soon cool the air it contains, and even though *A* is hot, *B* will be comparatively cold. A local circulation, of course, may take place in *a*, and some warm air may enter *B*, while a corresponding volume of cold air from *B* may fall by gravity down through *a*. The volumes changed in this manner will, however, be slight, because the rising current of the hot air will mix with the falling current of colder air and equalize temperatures. If we close *i* and open *h*, the cold air in *b* will descend, and the hot air in *A* will ascend; we shall thus have complete circulation within the apparatus without renewing the air.

This, then, is the principle of warming buildings by indirect radiation, and the reader will observe the analogy if he assumes *d* to be an indirect radiator, *c* the cold-air duct, *a* the hot-air duct, and *B* the room to be warmed. The pipe *k* represents any opening by which the air in the room may pass to the outer atmosphere, such as doors, windows, an open fireplace or a special vent-flue.

Fig. 3 shows how indirect radiators are commonly arranged to warm rooms on the ground floor. The radiator *a*, which is built up of sections spaced apart, is set in the middle of its casing, or box, in the same manner as *d*, in Fig 2, and is suspended by iron hangers from the joists of the floor above. Steam or hot water, as the case may be, enters the top of one of the end sections by the pipe shown, and leaves the radiator by a return-pipe. Fresh air enters through the register face, or grillwork, which is secured over the mouth of the cold-air inlet-duct *b*, made flush with the face of the wall, and passes through the radiator-box into the hot-air duct *c*, and then into the room above through a floor register, as shown by the arrows. This arrangement is so constructed that the room cannot be warmed without ventilation. If the radiator-box were furnished with another inlet-duct which would take a supply of air from the floor of the room, in the same manner as the tube *b* in Fig. 2 is arranged to take a supply from the bottom of the box *B*, the room could be warmed without ventilation.

This, however, in many respects is objectionable, because the same air is heated and reheated, breathed and rebreathed, and soon becomes vitiated, if the room is occupied. The reader will observe that the hot-air duct is taken from the side of the casing instead of from the top, as in Fig. 2, and is furnished with a flat bottom. This is particularly advantageous for floor-register connections, because any sweepings from the floor which may fall through the register will accumulate in the bottom of *d*, and can easily be removed by simply lifting out the register; it prevents the dirt from falling on the radiator and clinging to the castings, from which it will be carried up into the room in the form of fine dust.

Indirect radiators are often made to deliver

hot air into the rooms from wall registers located at different heights from the floors. Sometimes these wall registers deliver quite close to the floor, and at other times quite close to the ceiling.

The proper point of delivery will depend upon circumstances, such, for instance, as the outlet orifices from the room and the velocity at which the air enters the room. If the velocity of inlet is high, such as is obtained by forced draft or very tall hot-air ducts, the inlet-register is usually placed above the level of the heads of people in the room, so that currents of hot air cannot be detected; in such a case, the cold air or foul air, as the case may be, should pass off to the outer atmosphere through openings near the floor. If the velocity of inlet is low, say 3 feet per second or less, it is customary to deliver the hot air near the floor. When the rooms are not provided with special floor outlets, but depend upon crevices around windows and doors, etc. for an outlet of the cold or foul air, it is advisable to have the inlet-registers near the floor, so that the hot currents of air can stir up the cold air, which would otherwise stratify near the floor.

THE RULE OF MIXTURES.

George McC. Robson, M. A.

PRICE OF MIXTURE—SPECIFIC GRAVITY—MAPS DRAWN TO DIFFERENT SCALES—STOCKS.

ALLIGATION, or the Rule of Mixtures, is a very simple and useful arithmetical rule by which can be solved a great variety of examples, which, if otherwise attempted, would involve the use of algebra. This rule was originally devised to determine the ratio of the several parts of a mixture when the price of the mixture and the prices of the parts are known.

Rule.—Take the price of the cheaper part from the price of the mixture, and place the remainder under the dearer; take the price of the mixture from the price of the dearer part, and place the remainder under the cheaper. The ratio of these remainders is equal to the ratio in which the parts are mixed.

EXAMPLE.—How much tea at 36 cents per pound must be mixed with 60 pounds, at 42 cents per pound, so that the mixture may be worth 41 cents per pound?

SOLUTION.—Arrange the prices thus:

$$41 \qquad = \text{mean.}$$

$$\frac{36}{(42-41)} : \frac{42}{(41-36)}.$$

Or, $\quad 1 \quad : \quad 5 \quad$ = ratio of quantity of cheaper tea to quantity of dearer tea in the mixture.

The reason of the rule is obvious; for, on each pound at 36 cents there is a gain of 5 cents, while there is a loss of 1 cent on each pound at 42 cents; therefore, in order that the gains and losses may balance, with every pound at 36 cents, there must be mixed 5 pounds at 42 cents.

The solution is completed as follows:

5 pounds at 42 cents are mixed with 1 pound at 36 cents.

Or, 1 pound at 42 cents is mixed with $\frac{1}{5}$ pound at 36 cents.

Hence, 60 pounds at 42 cents are mixed with $\frac{60}{5}$ pounds at 36 cents.

Therefore, the answer is $\frac{60}{5}$, or 12 pounds at 36 cents per pound.

EXAMPLE.—A township containing 36 square miles has been mapped, partly to a scale of 6 inches to the mile, and partly to a scale of 4 inches to the mile. The area of these two maps together is 900 square inches. What area has been mapped to the 6-inch scale?

SOLUTION.—The scales of the maps are respectively 36 and 16 square inches to the square mile. If the whole township had been mapped to one average scale which would have given the same total area of map, then we would have,

$$\text{average scale} = \frac{\text{area of map}}{\text{number of square miles}} =$$

$$\frac{900}{36} = 25 \text{ square inches to the square mile.}$$

$$25 \quad = \text{average.}$$

$$\frac{16 \quad 36}{11 : 9} = \text{ratio of the parts.}$$

Therefore, for every 11 square miles mapped to 4-inch scale, there are 9 square

miles mapped to 6-inch scale. Hence, of every 20 square miles, 9 are mapped to 6-inch scale; or, of every square mile, $\frac{9}{20}$ is mapped to 6-inch scale. Therefore, the area mapped to 6-inch scale is $36 \times \frac{9}{20} = 16\frac{1}{5}$ square miles. Ans.

This rule enables us to solve a number of examples relating to specific gravity.

EXAMPLE.—The specific gravity of tin is 7.29, and the specific gravity of lead is 11.35. In what proportions must they be mixed to make a solder of specific gravity 10.44?

SOLUTION.—

$$\begin{array}{cc} \multicolumn{2}{c}{10.44} \\ 7.29 & 11.35 \\ .91 & 3.15 \end{array}$$

Therefore, the ratio of quantity of tin to quantity of lead is,

.91 : 3.15; or, 13 : 45. Ans.

EXAMPLE.—A vessel is filled with spirit whose specific gravity is .8146; when 4 ounces of the spirit are taken out and replaced by water, the specific gravity becomes .8517. Find the contents of the vessel.

SOLUTION.—The specific gravity of water is 1; hence we write,

$$\begin{array}{ccc} \multicolumn{3}{c}{.8517 = \text{mean}} \\ 1 & & .8146 \\ .0371 & : & .1483 \end{array}$$

Or, $371 : 1483 = 1 : \frac{1483}{371} = 4 : \frac{4 \times 1483}{371} = 4 : 15\frac{367}{371}$ = ratio of quantity of water to quantity of spirit in the mixture; and, as there are 4 ounces of water, there must be $15\frac{367}{371}$ ounces of spirit. But the water and spirit together fill the vessel. Therefore, contents of vessel $= 4 + 15\frac{367}{371} = 19\frac{367}{371}$ ounces. Ans.

EXAMPLE.—A man invests \$10,800 in stocks; part of it he invests in 3 per cent. stocks at 90, and the remainder in 4 per cent. stocks at 96. His income from the two investments is \$400.00. Find the sum invested in each.

SOLUTION.—In the first investment \$90.00 produces \$3.00 income, in the second \$96.00 produces \$4.00 income; hence,

Income per dollar in first $= \frac{\$3}{90} = \$\frac{1}{30}$.

Income per dollar in second $= \frac{\$4}{96} = \$\frac{1}{24}$.

Average income per dollar $= \frac{\$400}{10{,}800} = \$\frac{1}{27}$.

$$\begin{array}{ccc} \multicolumn{3}{c}{\frac{1}{27} = \text{average.}} \\ \frac{1}{30} & & \frac{1}{24} \\ \frac{5}{1080} & : & \frac{4}{1080} \end{array}$$

Therefore, the given sum is divided in the ratio 5 : 4. Hence, of every \$9, there is \$4 in 4 per cent. stocks; that is, the amount in 4 per cent. stocks is $\frac{4}{9} \times 10{,}800 = \$4{,}800$. The amount in 3 per cent. stocks is \$6,000. Ans.

ASSOCIATION OF IDEAS.

IT HAS been very truly said that the mainspring of memory is "association of ideas."

If we do not *understand* a thing it is practically impossible to remember it, but once understand it clearly, thoroughly, and logically, and it becomes part of ourselves. This is why it is so easy to remember the "reason why" a certain thing is so, if we have thoroughly mastered the reason in the first place. This is association of ideas—one thing suggesting another, as we say.

Try to understand, then, not to remember by rote like a parrot; and do not even *try* to remember things like numbers, formulas, dates, disconnected facts, etc. If you know that some such things will be of value to you in your business or otherwise, and you wish for that reason to have them at your fingers' ends, make notes, and only bother your memory with where your notes are, or in what book you can find the information or formula that you sometimes need, and you will find that, when occasion calls for the information, association of ideas, acting with lightning-like rapidity, will tell you where to find it.

MEMBERS OF A BRIDGE-TRUSS.

Benj. F. La Rue.

THE VARIOUS NAMES APPLIED TO THE DIFFERENT MEMBERS OF AN ORDINARY TRUSS-BRIDGE.

IT WILL be of interest to notice the various names applied to the different members of a bridge-truss and, in a general way, the offices that these different members perform as parts of the structure. When mentioned without reference to their positions in the truss, those members whose office is to resist compressive stress are generally designated as *struts*, or *compression members*, while those members which serve to resist tensile stress are known as *ties*, or *tension members*. In the truss, diagonal members that resist compressive stress are commonly called *braces*.

In Fig. 1 is represented, in simple outline, one of the vertical trusses of an ordinary Pratt truss-bridge. In this truss, all compression members are represented by heavy lines, and all tension members are represented by light lines, except the vertical tension members $B\,b$ and $B'\,b'$, which are shown heavy, because, in the best modern practice, these members are given the same general *form* as compression members. Certain diagonal tension members near the center of the truss are represented by dotted lines. The truss is symmetrical with reference to a vertical line through its center. Consequently, all joints of the truss at the right of the center are designated by the same letters (marked by a prime) as those by which the corresponding joints at the left of the center are designated. In what follows, therefore, it will be sufficiently clear if both of the members which are designated by corresponding letters are spoken of as one member, using the letters without primes. Thus, the member $B'\,c'$ corresponds to, and is interchangeable with, the member $B\,c$; in mentioning the member $B\,c$, both these members will be meant. With this understanding, the names of the respective members of this truss, which, in a general way, apply also to any truss, are given below. When more than one name is given for any member, the name first given is the one most commonly used.

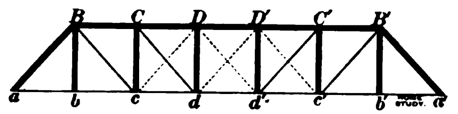


FIG. 1.

The joint a of the truss is called the *shoe-joint*, and the joint B is called the *hip-joint*. The upper horizontal member $B\,B'$ is called the *upper chord* and the lower horizontal member $a\,a'$ is called the *lower chord*. The member $a\,B$ is variously known as the *end post*, *inclined post*, *batter-post*, and *batter-brace*. The member $B\,b$ is called the *hip vertical*, *hip suspender*, or *long suspender*. The members $B\,c$ and $C\,d$ are called the *main ties*, or *main diagonals*. The members $C\,c$ and $D\,d$ are called the *intermediate posts*, or, sometimes, the *vertical struts*. The members $c\,D$ and $d\,D'$, shown by dotted lines, are called *counter-ties*, or, simply, *counters*. A counter-tie always crosses another tie; in some cases, it crosses another counter-tie.

In general, the two horizontal members $a\,a'$ and $B\,B'$ are called *chords*, and the remaining members of the truss are commonly known as *web members*. The end posts, however, may rather more properly be considered as being portions of the upper chord than as belonging to the web system. The portions $a\,b$, $b\,c$, etc. included between adjacent joints of the chord of the truss are called *panels*.

In Fig. 1, the outline of one truss only is shown; but at least *two* trusses are necessary in a complete bridge. In an ordinary bridge supporting a single roadway, the latter is carried between the two vertical trusses, which trusses are generally identical in every respect.

In order that the trusses may be held securely in a vertical position and prevented from collapsing sidewise under pressure of the wind, or from other causes, it is necessary that they be connected laterally by one or more systems of horizontal bracing. Girders or beams carrying the roadway must also be supported between the trusses.

Between the upper chords of the two trusses and between the upper portions of each pair of end posts, in a bridge of this type, is placed a system of lateral bracing, commonly known as the *upper lateral system*, though it is sometimes called the *overhead*

bracing. This is shown in outline in Fig. 2. The system of bracing *B B*, extending between the end posts, is known as the *portal bracing*, *portal strut*, or, simply, the *portal*. The names *super-strut* and *sub-strut*, respectively, are applied to the upper and

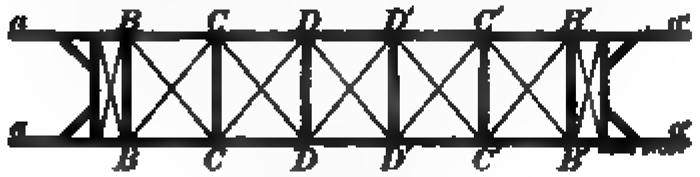


FIG. 2.

lower horizontal struts of the portal bracing, while the two diagonal rods between them are called the *portal sway-rods*. The short inclined braces, extending between the end posts and the sub-strut of the portal bracing, are called the *portal brackets*. The members *C C*, *D D*, etc. are called the *intermediate lateral struts*. The diagonal members *B C*, *C D*, etc. of the upper lateral system are called the *upper lateral diagonals*, *upper lateral rods*, or, simply, the *upper laterals*.

It is necessary that the two lower chords also be connected by a system of lateral bracing; this is called the *lower lateral system*. For the truss shown in Fig. 1, the lower lateral system is shown in outline in Fig. 3. The members *b b*, *c c*, etc. are the *floor-beams*, *floor-girders*, or *cross-girders*, by which the floor of the bridge is supported from the joints of the lower chords. The system of joists, plank, etc., supported by the floor-beams and composing the floor of the bridge, is spoken of as the *floor system*.

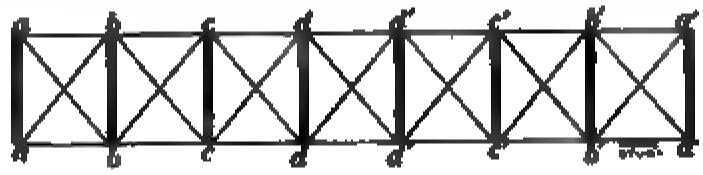


FIG. 3.

In bridges of this type, the floor-beams also commonly act as the intermediate struts of the lower lateral system. The members *a a* are called *shoe-struts*. The diagonals of the lower lateral system are known as *lower lateral diagonals*, *lower lateral rods*, or, simply, *lower laterals*.

The above comprise the names of the principal members of an ordinary truss-bridge, though other names are applied to some of the members of trusses of certain special forms. At the shoe-joints *a*, nearly all forms of trusses are supported upon pedestals resting upon the masonry; these are called *shoes*. Sometimes, ornaments called *pinnacles* are placed upon the upper chords at the hip-joints.

A HOME-MADE ARC-LAMP.

IN THE accompanying figure we illustrate a very simple form of hand-feed arc-lamp, which will show how the electric arc is formed, though it is of no value for lighting. Two supports *s*, *s*, about one inch wide, are drilled to receive two lead-pencils *p*, *p*, having the wood cut away so as to expose the lead. Connection is made to these cores by means of flexible wires *w*, *w*, these being connected at the other ends to terminals *t*, on the wooden base *b*. Wires from low-tension lighting-mains may be inserted in the terminals, but a fuse will also be an advisable addition to the circuit. The "carbons" being probably very impure, a good light should not be expected. The arc is started by touching the pencils together, after which they should at once be slightly separated to form the arc.

WATER-SUPPLY.

Cause of Sluggish Water-Supply—How the Supply May be Improved—The Overhead-Tank Method—The Compression-Tank Method.

IN THIS article we will consider some methods of improving a sluggish water-supply; but before we can suggest improvements, we must know the cause of the defective supply.

Suppose a building to be supplied with water from a source that is, say, half a mile away, the level of the water at the source being 100 feet above the level of the building. Despite this good head, a proper delivery of water cannot be obtained when two or more faucets are open at the same time. In fact, it is found that, when a faucet is opened in the basement or on the first floor of the building, water will not flow from any of the faucets on the top floor. This supposition may appear strange, but it is reasonable, nevertheless, and many buildings are affected in this manner.

It is quite true that the pressure of the water in the building will be that due to a head of 100 feet, or about 43 pounds by the gauge, when the water between the source and the building is at rest. When it is in motion the pressure at the building is considerably reduced, the effect of the head being consumed in overcoming friction and other resistances to the flow.

To obtain a clear understanding of pressure changes between water in motion and at rest, and how such changes affect the flow of water from faucets on the different floors of a building, let us refer to Fig. 1, in which two glass vessels *a* and *b* are open to the atmosphere on top, and a third vessel *c* is closed. We will close the cock *d* and the pet-cocks *e, f, g, h*, then pour water into *a*. The water will flow from *a* through the pipe and into *b* until the water-line in *b* is level with that in *a*. We now close the cock *i*, and open the four small cocks. The water will flow freely from each cock. This is because the pipe through which the water flows is large compared with the size of the pet-cocks, and is also comparatively short.

If the pipe were small in diameter or if it were very long, the volume delivered to the vertical pipe to which the small cocks are branched would be much less, probably just enough to flow out of the three lower cocks, as shown in the figure. Now suppose that we partly close the cock *j*, creating a resistance to the flow of the water equal to that required to cause water just to dribble out of *f* when all the pet-cocks are open; we shall then obtain a resistance to the flow equivalent to that offered by friction in a long line of pipe, or to a number of bends or other fittings upon the supply-line.

We now close *h* and water will flow more freely from *g* and *f*; a little may even trickle from *e*. If we also close *g*, the flow from *f* and *e* will be increased. Now close *f*, and *e* will deliver water very freely, full bore. By again opening all the pet-cocks, the water will flow from *f*, *g*, and *h* as before; but, by opening *i*, we have a different condition of affairs, because water will

Fig. 1.

flow freely and at full bore from each pet-cock, the vessel *b* supplying the deficiency. The good flow will continue until *b* is empty, when a poor flow, as shown in the figure, will again result.

We now close *i* and the pet-cocks, then open *d* and allow full pressure of the water due to the head between *a* and *c* to be exerted in *c*. The pressure will compress the air into the top of *c*, and a volume of water which will vary with the pressure will enter *c*. This volume of water will increase directly as the pressure increases, because the air decreases in volume inversely as the

pressure increases, and, by opening the pet-cocks, water will flow freely from all of them just as it did when b supplied them, but the flow gradually decreases until it reaches its original volume, i. e., that shown in Fig. 1. The cause of the temporary good flow in this case is that at the moment the pet-cocks were opened, the pressure was partly taken off c, and the air consequently expanded to a volume consistent with the new pressure; as it expanded some water was forced from c through d and the pet-cocks to the atmosphere. Of course, while the water flowed from c, the compressed air expanded, thus decreasing in pressure, and the flow from the pet-cocks consequently decreased uniformly and

FIG. 2.

slowly—not suddenly, as was the case when the supply from b was exhausted.

In Fig. 1, then, are shown two methods of temporarily converting a poor supply of water into a good supply, and the principles involved in these methods apply with equal force to systems of water distribution in buildings.

Fig 2 shows some plumbing in a building which is supplied with water from a reservoir up in the hills, probably about half a mile away. The reservoir, we will suppose, is about 120 feet above the level of the building; consequently, the pressure at the kitchen sink should be about 50 pounds by the gauge. This pressure is, if anything, a little too high for domestic service; a lower pressure, say about 40 pounds, would serve just as well.

Notwithstanding this high pressure it happens that, when the washtub-cocks are opened, no water will flow from the bath-cocks. This is due to the fact that the greater part of the head is consumed in friction by the water flowing through the long pipe c; this is equivalent to checking the cock g in Fig. 1.

To obtain a good flow at the fixtures when all cocks are open, the remedy employed for Fig. 1, i. e., either a low closed vessel filled with air, as at c, or an elevated open vessel, as at b, may with advantage be applied to the case illustrated in Fig. 2. The drawing shows a cylindrical reservoir b connected to the pipe-line between the reservoir a and the building. When the pressure due to the vertical height between the levels a and b comes upon b, the air contained within this vessel is compressed, in the same way as that in c, Fig. 1; and when the cocks in the building are opened, the effect of the air-compression in b will be to force water from b into the plumbing system of the building. In this way a good temporary supply can be obtained.

If a very large quantity of water is drawn off at one time, or, what is the same thing, if the cylinder b is too small, the pressure in b will be reduced too much before the desired quantity of water is obtained, and the effect of a decreasing pressure will be noticeable at the faucets in the building. A better arrangement than this, or, more correctly speaking, an arrangement which will give a better flow, is that of a tank in the attic of the building to supply all the plumbing fixtures except the kitchen and butler's pantry sinks. These should be supplied directly from the service-pipe, because cold water drawn at these fixtures will often be used for drinking and cooking purposes.

The chief objection to the plan shown in Fig 2 is that the air in b requires to be periodically replenished. The water absorbs the air at a rate varying with the pressure. As the pressure is increased the capacity of the water to absorb air is also increased.

The chief advantage of the underground tank b is that the water will be maintained at a more uniform temperature, and will be supplied to the building in a better condition than from a tank in the attic; it is also free from contamination by external influences.

LEVELING.

Benj. F. La Rue.

The Three Methods of Leveling—Method of Determining Differences of Elevation by Direct Leveling Explained—How to Eliminate the Errors Due to Refraction, Etc.

THE operation of *leveling* consists in determining the differences of elevation between given points on the earth's surface. The elevation of a point is commonly understood to be its distance vertically above or below a given level surface.

Differences of elevation are commonly determined by one of three general methods, namely:

First—By *direct leveling*, which consists in measuring the distances of the given points vertically above or below an imaginary horizontal line.

Second—By *indirect leveling*, which consists essentially in determining the altitudes of right-angled triangles by measuring their horizontal bases and adjacent acute angles.

Third—By the *aneroid barometer*. This method consists in estimating differences of elevation by the differences in atmospheric pressure.

Of these three methods, the first is the most accurate and by far the most commonly employed. It is for the purpose of leveling by this method that the engineer's leveling instrument is exclusively used, this

Fig. 1.

instrument being specially constructed for, and adapted to, this particular work. The operation consists in prolonging an imaginary level line, or, more correctly, a series of imaginary level lines, whose distances above or below each other are known or measured, and measuring the distances of the given points above or below these lines. It makes no difference in what *directions* the lines are prolonged, so long as they are level.

Each line of the series of imaginary level lines is established and prolonged by means of the engineer's level. The distance of a given point above or below the level line is measured by means of a measuring instrument called a *leveling-rod*. An engineer's wye-level is shown in Fig. 1. It consists essentially of a telescope having cross-lines in its optical axis at the point where the image is focussed to determine the exact line of sight; a sensitive spirit-level for indicating when the line of sight is level; and four leveling-screws, (in some instruments three) for adjusting it level.

There are various forms of leveling-rods, all quite similar in principle and more or less similar in form and construction. The leveling-rod shown in Fig. 2 is of the pattern known as the *New-York Rod*. In order to exhibit both ends of the rod, it is shown with a portion broken out of the center. This rod consists essentially of a compound maple bar about seven feet long, graduated to feet, tenths and hundredths of a foot, and carrying a target which, by means of a vernier, can be read to thousandths of a foot. The target slides along the rod and can be set in any position. The alternate quadrants of the target are painted red and white (sometimes black and white), as indicated in the figure, and it is set by moving it up or down until the horizontal cross-wire of the telescope exactly coincides with the

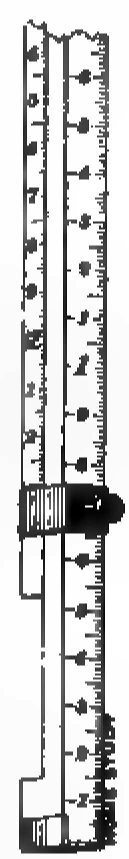


Fig. 2.

horizontal dividing-lines of the colors. The rod is graduated on its face from zero at the bottom up to six and one-half feet. But readings can be taken to twelve feet by setting the target at the six and one-half foot mark and sliding the back portion of the rod, which carries the target, upward, as shown in the figure. The distance of the center of the target above the bottom of the rod will then be indicated by graduations on the side of the rod. Although there are various forms of leveling-rods, the form here described, which is quite popular with engineers, will serve to sufficiently illustrate their general construction.

As stated above, a level line, or, more precisely, a line of apparent level, may be established by means of the engineer's level. When the level line has been established as a line of reference, the difference between the elevations of two points lying in the same vertical plane may be determined by either of the two following methods:

First Method—The leveling instrument is set up and leveled over one of the points, as the point B, Fig. 3, and the height of the center line of the telescope A, vertically above the point, is accurately measured and noted. The telescope is then sighted at the leveling-rod held vertically upon the other point, as the point C, and the height of the point where the level line of sight, as indicated by the cross-wire, strikes the rod, as at A', is observed and noted; or, to use the ordinary parlance of the engineer, the rod is *read*. If the rod is so far from the instrument that the graduations and numbers upon its face cannot be seen clearly, the reading is taken by so setting the target that the cross-wires of the telescope will exactly cut the dividing-lines of the colors. The difference between

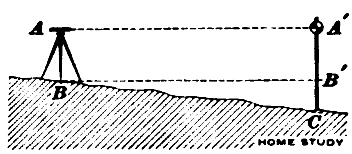


FIG. 3.

the height of the telescope and the reading of the rod will be the difference between the elevations of the two points. In Fig. 3, this difference is $B'C$, which is evidently the difference between $A'B'$ ($= A B$) and $A'C$.

This is really only the *apparent* difference between the elevations of the two points B and C, as the line $A A'$ is the line of *apparent* level and must be corrected for the error due to the curvature of the earth's surface and the refraction of the atmosphere, before the true difference between the elevations of the two points can be obtained by this method. The correction C, expressed in feet and fractions of a foot, for both curvature and refraction, is given by the formula,

$$C = \frac{D^2}{1.75},$$

in which D is the horizontal distance sighted, i. e., the distance $A A'$, Fig. 3, expressed in

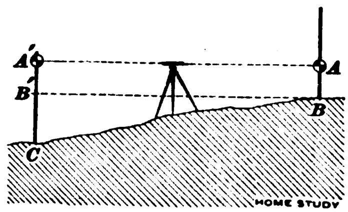


FIG. 4.

miles. From this formula it will be noticed that the correction is in proportion to the square of the distance sighted. When the distance D, or $A A'$, is short, the error will be slight, but when it is of considerable length, the error will be considerable and the correction must be applied. This method of determining differences of elevation is not so extensively employed as the method which will now be explained.

Second Method—In Fig. 4, let C and B represent the two points between which it is desired to determine the difference of elevation. For this method, the instrument is set up at any point from which the two given points can be seen and which is of such a height that the line of sight of the instrument, when leveled up, will pass above the highest of the given points. The telescope is sighted at the rod held vertically upon either point, as the point B, and the point where the line of sight strikes the rod is observed, the rod-reading being recorded in a note-book kept for the purpose. The rod is then held at the other point C and the operation is repeated. *The difference between the two readings of the rod will be the difference of elevation between the two points.* The height of the line of sight $A A'$ above either point is quite a matter of indifference.

In leveling by this method the error due to curvature and refraction may be corrected for each sight, the same as for the method first explained; but, by reference to the formula for correction, it will be noticed that the amount of the correction is directly

proportional to the square of the distance sighted. Hence, in determining the difference of elevation between two given points by the method just explained, if the leveling instrument is so placed as to be at equal distances from the two points, the errors in the two lines of sight, due to curvature and refraction, will be exactly the same and will just balance each other, so that *no correction will be necessary.* In other words, the difference between the elevations of the two points, as determined by the two *equal* lines of apparent level, will be the same as though determined by lines of true level. The errors will be eliminated by this process because they will just balance each other; that is, if the corrections were actually applied in determining the difference of elevation, one would be deducted from the minuend and one from the subtrahend, and, being equal, the remainder would be the same as if the corrections were not applied.

Differences of elevation may be obtained more accurately by this method than by the method first explained, because the error due to refraction varies somewhat with the state of the atmosphere and, therefore, cannot be estimated with exactness, whereas, if the two sights are equal, the error will be entirely eliminated, whatever it may be. It is not necessary for the leveling instrument to be *in line* between the two

FIG. 5.

points, it may be set up in any convenient position, so long as it is at equal distances from the points; nor is it necessary that the distance from the instrument to each of the given points shall be accurately measured. As, for a distance of a few feet, the correction is so exceedingly small as to be practically nothing, being less than three thousandths of an inch for one hundred feet, it follows that the equality of the sights can be judged by the eye with sufficient accuracy.

Let it now be assumed that the difference in the elevations in the two points A and C, Fig. 5, is so great that it cannot be determined in the manner described above. If the leveling instrument is set up so as to sight just above the ground at A, it will sight considerably above the top of the rod when held at C, as shown in the figure; so that, though the level line of reference can be established by the instrument, the distance of both given points below this line cannot be

FIG. 6.

measured by the rod. Hence, some other method of procedure must be resorted to. Whenever it is found that the rod, when held upon the required point, cannot be sighted by the level, the rod should be read upon some intermediate point, the level moved forward and again set up at a suitable place, sighted first upon the rod held on the same intermediate point and then upon the rod held upon the required point. This is clearly shown in Fig. 6. It is evident that the difference between the elevations of the points A and C will be the difference between the readings of the rod on the points A and B, with the instrument at m, plus the difference between the readings of the rod on the points B and C, with the instrument at n.

In leveling in the direction from A to C, with the instrument set up at m, the sight upon the rod at A is called a *backsight* and the sight upon the rod at B is called a *foresight.* Similarly, when the instrument is moved forward to n, the sight upon the rod, when held at B, is a backsight and, when held at C, it is a foresight. *The difference between the sum of the backsights and the sum of the foresights will be the difference of elevation between the first and last point sighted.* The point B, Fig. 6, upon which both a foresight and a backsight are taken for two respective positions of the instrument, is called a *turning-point.* The rod is held on a turning-point, determining the elevation of

the point, and remains held at the point while the instrument *turns*, that is, while it is moved forward and set up at another point. It is evident that, when the instrument is set up at m, the elevation of any desired point between A and B may be determined by simply sighting the instrument at the rod held upon the point. When the instrument is at n, the elevation of any desired point between B and C may be determined in like manner. Points between the turning-points, whose elevations are thus determined, are called *intermediate points*.

The system of leveling indicated in Fig. 6 may be extended indefinitely, so that the difference of elevation between any two points, however far apart, may be determined by running a line of levels between the two points. The rule given above for determining the difference of elevation between the first and last point sighted is perfectly general, and will apply without regard to the number of turning-points between, so long as the rod-readings upon *turning-points only* are considered. In running the line of levels, the elevations, not only of all turning-points, but also of any number of intermediate points may, at the same time, be determined. The line of levels may run up-hill or down-hill, or alternately up- and down-hill; it will make no difference with reference to the applications of the principles involved. It will be evident, however, that, in running any extended line of levels, some brief and systematic method of keeping a record of the rod-readings must be employed, which will be at once concise, explicit, and convenient for computing and recording the elevations.

ELECTRICITY FROM WIND-POWER.

How to Build a Wind-Motor—Tower and Tower-House—Size and Construction of Wheel and Vane—The Arrangement of Shafting, Gearing, and Dynamo.

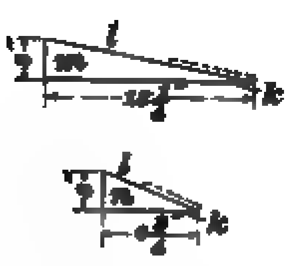
"*Kindly give me a few instructions on how to build a wind-motor for running a one-fourth-horsepower dynamo. What should the paddles be made of, how many should there be, and of what shape? How should the wheel be set up so as always to face the wind? What gearing should be used to obtain an armature speed of 2,200 revolutions per minute?*"

The above question was sent in by a subscriber, and, since the answer cannot be made as full as it deserves to be in the limited space of our inquiry columns, we make it the subject of a short article.

In order that the windmill may have sufficient surplus power to overcome the frictional resistance of the gearing, and to supply extra power in case of an emergency, the diameter of the wheel should be about 16 feet. The accompanying figure shows the essential details. At the left is a view of one-half of the face of the wheel, showing the arrangement of the blades. It is built up in 8 sections, containing 11 blades each, or 88 blades in all. The blades should be made of well-seasoned ash, smoothly planed to one-fourth of an inch thick. They should be 5 feet 4 inches long, and cut to a taper, being 4 inches wide at the end farthest from the center of the wheel and 2¼ inches wide at a point 4 feet 6 inches from the outer end, as shown at a.

The frame is built of 8 pieces b of ash or hard maple, each 7 feet 2 inches long and 2 inches square, put together at the center like the spokes of a wagon-wheel and bolted between the two hub-plates c with ⅜-inch carriage-bolts. The hub-plates should be about 8 inches in diameter and ⅜ of an inch thick, with a boss, or projection, at the center, 2 inches long and 2½ inches in diameter, to give the wheel a good bearing on the shaft. At distances of 3 feet, 5 feet, and 7 feet from the center are nailed or screwed the cross-pieces d (one on each side) of 2-inch by 1½-inch ash or hard maple, notched at each end $\frac{3}{16}$ of an inch deep, so that the space between them for the blades will be ¼ of an inch wide. The angle of the blades with the face of the wheel varies, growing smaller as the outer end is approached. To set the blades properly requires a little care. First, take a perfectly smooth and flat board and lay off the two triangles m and n to the dimensions given in the figures. Next, cut out the triangles and trim to the lines l and k. These now become gauges for setting the blades. Then place the blade between the

cross-piece *d* with the wheel lying on its face on a perfectly flat bench, or floor, on which has been described an arc with an 8-foot radius, and with the hub just over the center of the circle of which the arc forms a part. A peg driven through the hub into the floor will serve to keep the wheel in place. The widest end of the blade is now brought just up to the arc and held in place with the gauge *m* between it and the floor, the blade being held snug against the edge *l*, as shown by the dotted lines. Next, measure 4 feet 6 inches from this point toward the center of the wheel and place the gauge *n* between the blade and the floor at this point. The blade will then be seen to have a slight twist, and it should be fastened to the bars *d* in this position with small triangular blocks to hold it in place.



The hub-plates should be drilled with a 1½-inch twist-drill and the wheel set on the shaft with a key and two set-screws, so that its center is 1 foot 5 inches from one end of the shaft. The shaft should be 1½-inch turned wrought iron, 4 feet 6 inches long. Two collars *y*, each with 8 holes drilled near the edge, are fastened to the shaft 1 foot 4 inches from the center of the wheel, and, from these, sixteen ¼-inch iron rods *r* (8 on each side of the wheel) are fastened to a point on *b*, 3 feet 10 inches from the center of the shaft. The shaft passes through the forked bearing *f* as shown. This bearing is a casting with a broad base, which sets over a cone on top of the tower and revolves about this cone as a center, allowing the wheel to be turned into the wind by the vane *V*.

Running up through the center of the tower is a vertical shaft *s* which drives a countershaft in the small room built about the top of the tower just below the wheel. On the wheel-shaft is a bevel-gear *x*, 8 inches in diameter, which meshes into the gear *z*, 4 inches in diameter, on the shaft *s*. On the lower end of *s* is a bevel-gear *p*, 8 inches in diameter, meshing into a gear *q*, 4 inches in diameter, on the countershaft. The countershaft carries a pulley *o*, 24 inches in diameter, from which a belt running on a 2-inch pulley on the armature-shaft of the dynamo gives the required speed when the wheel of the windmill is revolving at 45 revolutions per minute. The vane *V*, set at right angles to the face of the wheel, keeps the wheel "up to the wind." It should be arranged so that it may be swung parallel to the wheel-face when the wind gets too high for the safety of the apparatus. The wheel will then keep its edge to the wind. The vane is built up of slats as seen. The

principal dimensions are given in the figure. The height of the tower should be at least 40 feet. The balance of the details will be left to the ingenuity of the builder.

To run a plant of this kind successfully requires some means of obtaining current when there is no wind, or when the wind is not sufficiently strong for the power required. Some device for keeping the electrical pressure at the required figure should also be employed. For supplying current when the wind is light, or during a calm, it is customary to use a storage-battery. It has also been proposed to run a pump in connection with the windmill and to store water in a tank, or convenient reservoir, using the water to run the dynamo by means of a turbine.

To steady the electrical pressure when the dynamo is run directly from the windmill, as in the figure, three separate methods can be employed. A specially wound dynamo, giving a constant pressure over a wide range of armature speeds, is belted directly to the countershaft; an ordinary dynamo is driven by a pair of cone pulleys placed between it and the countershaft, a governor on the pulleys regulating the speed ratio between the countershaft and the armature; or, an automatic regulator is arranged to place storage-cells in circuit with the dynamo, as the speed falls, and cut them out as the speed rises.

LAYING HOUSE DRAINS.

Thomas N. Thomson.

Choice of Material—Reinforced Pipe-Sockets—The Right Diameter and How it Can be Determined—Table of Grades.

THE *main house drain* is that line of pipe which conveys all the sewage matter from the several fixture-branches and pipe-stacks in a building to a point outside of the building.

The *branch house drains* are those pipes which connect the main house drain to the several pipe-stacks. They receive discharges from the pipe-stacks and deliver them into the main drain.

The *house sewer*, or *sewer connection*, is that pipe which receives the discharges of the main house drain and delivers them to the street sewer or other place of disposal.

There are many important points to be considered in laying out and fitting up the several lines of pipe which constitute the house drains. Probably the first thing to be considered is the *material* of which the drains should be made. This may be cast iron, wrought iron, steel, brass, or copper. Cast iron is the metal most commonly employed for this work, the grade, or quality, being known to the trade as "extra heavy."

These pipes should be coated both outside and inside with asphaltum to prevent corrosion of the iron. The socket, bell, or hub, of each pipe and fitting should be reinforced around its mouth with a thick rim of metal to prevent it from being split by calking lead into the joints.

The *fittings* employed in all house-drainage work should have "easy sweeps," that is to say, all bends should have easy curves (not sharp or abrupt) and all branches should join the main drain at an acute angle. The standard branch-fittings to be found on the market are made to take the branches at an angle of 45° and are called Y branches.

Right-angle branches, commonly called tees, and short or sharp right-angle bends, or elbows, should never be permitted in house-drainage work, not only because they are very liable to become choked, but also because they prevent the free and easy flow of the sewage and thereby prevent the proper cleansing of the drains.

The *size* of a house drain, or, in other words, its internal diameter, should be just large enough to do the work. If it is too small, the drain will be very liable to become choked or entirely filled with sewage by a simultaneous discharge from a large number of fixtures. Experience has taught us that if the pipes are too large, an adequate volume of water cannot be obtained by the ordinary flushing of plumbing fixtures, and the internal surfaces of the pipes,

consequently, cannot be thoroughly cleansed without the aid of special flushing arrangements. In extremely large pipes, the volume of water delivered is actually too small to form a depth in the pipe sufficient to float solid matter to the point of outlet. The solids consequently remain in the pipe, decompose, and thus generate gases of a dangerous character. Practice has taught us that a 4-inch drain, if laid straight and with a proper fall, is sufficient to carry off the usual quantity of sewage from an ordinary building equipped with two water-closets, two baths, two or three basins, one pantry sink, one kitchen sink and one set of three washtubs. A 5-inch drain will easily take the discharges from twice to three times as many fixtures, and a 6-inch drain-pipe will take five or more times the number of fixtures specified.

In fact we find in practice that, if roof- or storm-water does not enter the drains, larger sizes than 6-inch are very seldom required. No house drain which takes the discharge from a water-closet should ever be less than 4 inches in diameter; a 3-inch drain may, however, be laid to take away waste water from a few baths, basins, or sinks.

The *location* of the main house drain is next to be considered. This will depend entirely upon the existing conditions. In all cases it is proper to run the drain in as direct and straight a line as possible, and always above the cellar-floor when practicable. There are several reasons for this; the first is that the pipe can easily be inspected when desired, and leaks can be readily detected. The second reason is that the pipe can be easily opened and cleared of a chokage at any point. The third reason is that the pipe will last much longer above the floor than when buried underground, because it will then not be subject to the corrosive action of the earth.

When circumstances demand that the drain-pipes shall be run under basement or cellar-floors, they should, if the expense is not too great, be laid in specially prepared channels, or tunnels, which are furnished with movable covers laid flush with the floor; they will then be almost as accessible as drains which are run above the floors and in open view.

The *pitch*, or grade, of the drains is a very important matter and requires consideration, because it governs the velocity of the flow of the sewage. The power of the water in the drains to carry away solid matter which falls into them from the fixtures above, depends upon two things: first, the depth of the water in the pipe, and second, the velocity of the flow; this simply means that the requirements of a good drain as regards its flushing or self-cleansing qualities, are a volume of water sufficient to immerse or float the solids, and a velocity of flow sufficient to carry the solids forward to the sewer. If the depth of the water is too small, the solids will then touch the bottom of the pipe and the contact will retard their forward motion to such an extent that the water will move more quickly than the solids and thus leave them behind to putrefy in the drainage system or be carried forward by the next flush. Thus it would appear that, if the pitch of a drain is too steep and the water flows through it with a velocity which is too high to produce the desired depth of flow, the solids will remain in the pipe and the water will flow ahead of them. If the pipe is so steep that the solids cannot lie in it, such for example as in a pipe whose pitch is 45° or more, then, of course, the solids will simply slide or roll forward and probably be discharged along with the water.

Now, since the solids cannot be carried forward with the desired efficiency through level or nearly level drains, because of lack of velocity, and since they cannot be efficiently carried forward through drains which have too great a pitch, because of lack of depth of water to float them, we are led to the conclusion that there is such a pitch, or certain pitches, for different sizes of pipes which will ensure such a velocity that the pipes may be made self-cleansing.

The desirable velocity, as determined by practical observations, is about 250 to 275 feet per minute, or from about 4 to 4.5 feet per second.

In order to obtain this velocity in the different sizes of pipes, different pitches are required; they are about as follows:

Sizes of Drain-Pipe.				*Pitch.*					
2-inch	inside	diam	1-inch	fall	in	20	inches	length.
3 "	"	"	1 "	"	"	30	"	"
4 "	"	"	1 "	"	"	40	"	"
5 "	"	"	1 "	"	"	50	"	"
6 "	"	"	1 "	"	"	60	"	"
7 "	"	"	1 "	"	"	70	"	"
8 "	"	"	1 "	"	"	80	"	"
9 "	"	"	1 "	"	"	90	"	"
10 "	"	"	1 "	"	"	100	"	"

If different sizes of pipes are all laid with the same pitch, say ¼ inch per foot, as is commonly specified, different velocities will be obtained in different parts of the drainage system.

HINTS TO HOME-BUILDERS.

Louis Allen Osborne.

WHY HOUSES COST MORE THAN THE ORIGINAL ESTIMATES—HOW THIS CAN BE OVERCOME—THE CAUSE OF "EXTRAS."

EVERY person who proposes to have a house built for himself starts out with the idea of having it well built and of low cost; and, with each of these important considerations ever present in his mind, the prospective house-owner makes many errors that materially interfere with the successful achievement of his ideal.

Ninety-nine house-owners out of every hundred will tell you that a house *always* costs from twenty-five to fifty per cent. more than the original estimate, and that architects or builders never consider the fact that the owner's pocketbook is limited to the figure he originally states.

Now, whose fault is this? Is it impossible for a man to start out with $2,000 or $3,000 and build a house that will cost $2,000 or $3,000, no more and no less? Most certainly it is not, and the trouble lies sometimes with the architect, sometimes with the builder, very often with the owner, and, not at all infrequently, with all three.

As a matter of fact, very few house-builders have the remotest idea what kind of a house they can build with the means at their disposal, and the over-zealous builder is more inclined to show plans of various houses which are *above* the owner's limit, than to submit sketches which he knows are well within the proposed building price.

The prospective owner thereupon acquires very fine ideas of his house, and adds here and there a detail "which costs only a few dollars," until the estimate of cost shows up way beyond the limits of the owner's bank account. Trouble then ensues. The owner blames the architect or builder for drawing plans that represent a too costly house; he declares he has seen houses "just as big and just as fine built for the figure he wants to pay." The architect declares that the house is an unusually well-planned one and could not be satisfactorily reduced in dimensions to cut down the price. A compromise is then effected, where the owner decides to leave out the hardwood trim in two of his rooms, to have a cellar under only part of the house, and to submit to some other *minor* alterations of details. The builder agrees to make certain concessions, the architect alters the drawings, and the contract is then let for less than the previous estimate but, at the same time, for more than the owner's original idea of what he wanted to spend on his home. Now, all this is very wrong and, what is more, absolutely unnecessary; no good can come of it to any of the parties concerned. The owner starts out to lay the foundation of his home with a prospective mortgage. The builder has signed a contract to do work which he knows he will have to "skin" if he is to get his profit out of it, and the architect has entered into a compact which he should know cannot be carried out unless either the owner or the builder is *stuck*.

When the house is finished, the owner is disappointed because it does not suit his requirements. The builder is worrying over a long bill of *extras* which the owner has ordered and the architect refuses to *O K*, and non-payment of certificates, mechanics' liens, and lawsuits are threatened on all sides. Is it then a wonder that ninety-nine out of every hundred house-builders make the statement mentioned in the first part of this article?

The cost of a house is simply a question of business management, and it should always be borne in mind that it is by no means economical (for either party) to make a contract to have a home built for less than it is worth. A given quantity of material combined with a given quantity of first-class labor is worth a certain amount of money, and no amount of argument can make it cost less, any more than $2 + 4$ can be made to equal 5. A well-built house can be secured only through the employment of good and competent mechanics, and, though the contract may be most binding and secured by a forfeiture bond, this contract or bond will not make a poor mechanic do good work, when he does not know how.

The prospective home-builder should not go to his architect until he knows what he wants, and the architect should not raise his hopes or ideas until all the details of

the proposed dwelling are thoroughly understood. Let each room be considered separately before a plan is drawn. Let every detail of approximate size, character of finish, quality of floors, style of hardware, finish of plaster, etc., etc. in each room be thoroughly understood before the approximate cost is figured. Remember at the beginning that it makes much difference in cost if the cellar is to be cemented, the bathroom tiled, the attic plastered, etc., and if these items are shown in the first place there are no disappointments later on, and the architect will know from experience whether or not he can carry out his client's ideas with the money at his disposal. If these details are properly attended to, there will be no extra bill at the end of the work and the house will cost exactly what it was contracted for. The owner gets what he wanted, the builder receives his payments promptly, the architect's reputation is unimpaired, and everybody is happy.

Suppose a man wants to build a house for $2,500, and so expresses himself to his architect. The latter, if experienced, will know just about how much can be done for that amount of money, and immediately forms a mental idea of a $2,500 house-plan. But if the prospective owner desires hardwood floors, open fireplaces, extensive verandas and other luxurious details, then the extra cost of these over the plain finish must be *deducted* from the above amount, and the remainder taken as the expenditure for which the house must be planned to suit.

For example, suppose the above owner desires to have his dining-room and his entrance-hall floored in oak, his parlor, dining-room, and entrance-halls to have open fireplaces and mantels, his entrance-door to have a plate-glass panel, his cellar to be cemented, a furnace to heat the whole house, and an extra room finished off in the attic. Then the first duty of the architect is to estimate the costs of these items in some such manner as follows:

Oak floor in dining-room	$ 17.50
Oak floor in hall	12.00
Three fireplaces and mantels	150.00
Cementing cellar	60.00
Plate glass in front door	12.00
Furnace	200.00
Dresser in kitchen	18.00
Room in attic	25.00
Total	$494.50

These prices are of course only approximate, and would vary materially according to circumstances, but they serve not the less to show that in planning our house we must figure the cost to be about $2,000 and leave $500 for incidentals. The owner must then be informed as to what he can do for $2,000 and not be led to believe he can change this or alter that without affecting the cost of the house—for every alteration costs money if the change is made after the contract is signed.

The architect is the mediator between the owner and the builder. His duty is to see that the former gets exactly what he pays for and that the latter carries out the work according to contract. He must not let the owner be imposed upon nor permit the builder to accept a contract at a price inconsistent with the class of work required. The owner pays his architect not for his plans, nor for his superintendence, but for his services in general—on the same principle that he would pay his lawyer to take charge of his case and endeavor to do the best he could to win his suit. To his lawyer he states his case and opinions, and leaves the question of the proper line of prosecution or defence to the man he has employed. To his architect he states his desires and his limits of expenditure, leaving to the practical designer the question of how they are to be combined in the house-plan. If the owner's desires cannot be carried out for the money he has at his disposal, it is just as much the architect's duty to so inform him as it is the lawyer's duty to tell his client he has "no case" when he knows this to be so.

When the builder himself is drawing the plans for a house, he is naturally disinclined to discourage the prospective house-owner, as, thereby, he does himself out of a job; but, notwithstanding this, it is always better to have a man give up the project of building, than have him worry along through the period of house construction, becoming more and more discouraged each day at the growing expenses or necessary curtailings and finally ending up with a house on his hands that is neither a convenience in itself nor a credit to its builder.

Parties that build for themselves houses costing less than $3,000 are, in the majority of cases, persons who have earned the money and saved it and know very well what sacrifices each dollar has cost. They want to buy as much as they can with that money and therefore set their ideas high, and are often led to overreach their limit in the endeavor to have the money well invested.

Take a long time to consider what you

want. Make a daily memorandum of the items that come to your mind which you wish to see exemplified in your house-plan. Don't go in for a lot of ornamental detail which costs money but which neither keeps the house warm nor makes it convenient. Get a complete list of what you want and also what you are sure you *don't* want, and then, but not till then, consult your architect or builder.

DINING-ROOM ASPECT.

TOO little attention is given the subject of *aspect* in the planning of modern country dwellings, and few builders seem to appreciate the fact that it makes a vast difference whether the room faces the north, south, east, or west.

The dining-room, for instance, should *never* face the west; first, because at the hour of the evening meal, the long level rays of the setting sun would materially interfere with the comfort of the diners, unless the shutters were tightly closed, and this would be decidedly unpleasant in summer; second, because the sun, shining on the west side of the house all the afternoon, would render the dining-room almost unbearably hot in summer, from noon until after sunset. And third, because, during the shorter days of the winter season, such room would be dark, cold, and cheerless during breakfast time.

Therefore, let the dining-room face the east or south, where it will be warm and cheerful in winter, and cool and comfortable in summer. Let it have broad liberal windows, at the end of the room, rather than on the side; as in the latter case one-half of the diners would have the light in their eyes, while the others would be compelled to eat with the shadows of their heads falling across their plates.

If circumstances are such that the light *must* be admitted at the side, let the dining-room have a large window at each end of its side wall, and always avoid a group of windows, or a bay in the center, unless additional light can be admitted from the end or opposite side.

A CENTURY CALENDAR.

31 Dec.	1	2	3	4	5	6	7
	M 1	T 1	W 1	T 1	F 1	S 1	**S** 1
—	T 2	W 2	T 2	F 2	S 2	**S** 2	M 2
2	W 3	T 3	F 3	S 3	**S** 3	M 3	T 3
—	T 4	F 4	S 4	**S** 4	M 4	T 4	W 4
3	F 5	S 5	**S** 5	M 5	T 5	W 5	T 5
—	S 6	**S** 6	M 6	T 6	W 6	T 6	F 6
4	**S** 7	M 7	T 7	W 7	T 7	F 7	S 7
—	M 8	T 8	W 8	T 8	F 8	S 8	**S** 8
7	T 9	W 9	T 9	F 9	S 9	**S** 9	M 9
—	W 10	T 10	F 10	S 10	**S** 10	M 10	T 10
1	T 11	F 11	S 11	**S** 11	M 11	T 11	W 11
—	F 12	S 12	**S** 12	M 12	T 12	W 12	T 12
5	S 13	**S** 13	M 13	T 13	W 13	T 13	F 13
—	**S** 14	M 14	T 14	W 14	T 14	F 14	S 14
6	M 15	T 15	W 15	T 15	F 15	S 15	**S** 15
—	T 16	W 16	T 16	F 16	S 16	**S** 16	M 16
[illegible]	W 17	T 17	F 17	S 17	**S** 17	M 17	T 17
—	T 18	F 18	S 18	**S** 18	M 18	T 18	W 18
6	F 19	S 19	**S** 19	M 19	T 19	W 19	T 19
—	S 20	**S** 20	M 20	T 20	W 20	T 20	F 20
4	**S** 21	M 21	T 21	W 21	T 21	F 21	S 21
—	M 22	T 22	W 22	T 22	F 22	S 22	**S** 22
2	T 23	W 23	T 23	F 23	S 23	**S** 23	M 23
—	W 24	T 24	F 24	S 24	**S** 24	M 24	T 24
7	T 25	F 25	S 25	**S** 25	M 25	T 25	W 25
—	F 26	S 26	**S** 26	M 26	T 26	W 26	T 26
5	S 27	**S** 27	M 27	T 27	W 27	T 27	F 27
—	**S** 28	M 28	T 28	W 28	T 28	F 28	S 28
3	M 29	T 29	W 29	T 29	F 29	S 29	**S** 29
—	T 30	W 30	T 30	F 30	S 30	**S** 30	M 30
1	W 31	T 31	F 31	S 31	**S** 31	M 31	T 31

CURRENT TOPICS.

Mrs. F. R. Honey.

THE WAR IN INDIA.—Nature has fixed the boundaries of the Indian Empire. It is separated from the rest of the world by lines as clear and distinct as if the peninsula were an island. Its northern limit is the range of mountains called the Himalayas, "the abode of snow"—a great white wall which divides India from the table-land of Central Asia. This range includes the highest peaks in the world, and is practically impassable. Here and there are points at which a few hardy mountaineers can make their way, but no army could possibly be transported across this natural fortification. At its western extremity is the high table-land known as the Pamir, "the roof of the world," the meeting-place of three empires, the British, the Russian, and the Chinese, which control, at present, the destinies of Asia.

The northwestern boundary of India, from the Pamir to the Arabian Sea, is not so securely protected. Through the mountain chains which divide India from Afghanistan are passes which, from time immemorial, have served as the gateway for invading forces, and the control of these passes is necessary for the security of the Indian Empire. The British government long since established friendly relations with the independent tribes who inhabit this wild and mountainous region, and treaties were made with the tribesmen binding them to keep the peace among themselves and with their powerful neighbor. Subsidies were paid to them, in return for which they engaged to maintain order, and to protect the persons and property of all who travel through these passes.

To those who have studied the character and habits of these warlike frontier tribes it is manifest that a controlling influence of some kind must be exercised over them in order that public quiet may be preserved on the border. Neither savages or semisavages can be treated with on terms of equality. If civilization and barbarism are to exist peaceably side by side, civilization must have the upper hand and barbarism must know it. As a matter of fact, barbarism recedes before civilization, or becomes absorbed by it, as is illustrated in the history of the relations between the Europeans and the red men in the settlement of the North-American continent.

The territory of Russia is very near the Indian frontier on the northwest, and, whether rightly or wrongly, it is believed by many that Russia would not neglect any opportunity which might offer itself to extend her empire southward, and thus to endanger the British rule in India. The weakening of the frontier by constant disturbances among hostile tribes might afford this opportunity; for, if one great power retires or surrenders its influence, it invites the other to step in and exercise authority to subdue disorder. British statesmen do not forget these facts when plans are made for the defence of the Indian frontier.

The mountainous region between India and Afghanistan is the scene of the war which is now in progress. Peshawur, a town in the northwest corner of India, can be found on any map. The Tochi Valley to the south, the Swat River to the north, and the Tirah Valley to the west are the limits, roughly speaking, of the disturbances that have taken place, and none of these are more than a hundred and fifty miles in a straight line from Peshawur. But in such a country it is impossible to travel in a straight line. Its surface has been compared to that of a plowed field, with every little roughness, depression, and elevation magnified a thousand times. There are no roads, the defiles and passes among the hills are narrow and winding, and a more difficult country in which to carry on a war can scarcely be imagined.

The outbreak with which the present war began came like a bolt out of a clear sky. On June 10th, 1897, a British civil officer was traveling with an escort of soldiers through the Tochi Valley. His errand was to collect fees and to make some peaceful arrangements with the Waziris, a tribe in that locality. Without warning, while resting in the heat of the day, the party was attacked and several were killed. A month later, in the Swat country, 200 miles distant, a fanatical Mohammedan prophet proclaimed a "holy war," and the tribesmen sprang to arms: for they believe that the

slaying of a Christian is a meritorious act, and that if a Mohammedan falls while fighting with a Christian he will go straight to Paradise.

Measures were taken to repress these disturbances, but a more serious incident soon occurred at an important point. The tribe of the Afridis had made a treaty with the Indian government in 1881 to guard the Khaiber Pass, the main road from Afghanistan through the mountains, and for this work they received an annual payment of money. Under this compact the British had lived in peace with them for sixteen years, when suddenly they seized the pass, destroyed the small fortifications erected for its defence, and called their countrymen together to resist British power. Some weeks elapsed before the necessary troops and supplies were assembled at Peshawur, and meanwhile the tribesmen gathered to the number of 40,000, determined to oppose the intrusion of foreign soldiers. It was the proud boast of the Afridis that no white men had ever invaded their stronghold; and, armed with modern weapons and familiar with every point of vantage in their native hills and valleys, they were prepared for a stubborn fight. They are born soldiers; many of their race have served in the British army, and have been found brave and faithful.

But, with every natural vantage in their favor, they cannot resist the steady, resolute attack of disciplined troops. They have gradually fallen back; section after section of unknown country has been entered and surveyed by British forces; battles have been fought in winding valleys and on steep hillsides; the natives have been dislodged from one point after another, and while they have sometimes gained temporary advantage in a sudden attack from the hills, or on the rear-guard of the troops, who have long baggage trains to protect, yet slowly but surely they have retreated before their conquerors. Most of the tribes have sent in their submission and agreed to the terms of peace, surrendering their weapons and paying fines. The advance of the British forces ceased when the severe cold of winter set in, but the tribesmen have been warned that every one of their settlements will be visited either in peace or in war before the army is withdrawn from their mountains, and it is expected that a short spring campaign will terminate the struggle and reduce the country to order.

It is often the case that in the course of a war some picturesque and romantic incident of especial interest occurs, which attracts attention and appeals to the imagination of all who hear of it, and which thus becomes historic. Of such a character is the charge of the Light Brigade in the Crimean War, or the relief of Lucknow in the Indian mutiny, or deeds of heroism done by individuals or by companies in the wars of this country. Such stories are enshrined by poets in song, they are told to children at the fireside, they inspire a longing in youthful hearts to do like deeds of glory; and, ere many years have passed, they become an indelible part of the national history. Other acts may have been as brave, other risks as great, other men as resolute; but circumstances make such incidents stand out in a high light, and embody in the popular mind the idea of the whole campaign. Such a scene in the frontier war is the capture of Dargai Bridge. This point, a precipitous cliff of more than two hundred feet in height, and approachable only by a steep and narrow path, was won by the British on October 18th, but as it appeared to be of no especial importance, no attempt was made to hold it. On the morning of the 20th it was seen to be occupied by a large body of Afridis, who stopped the advance of the troops. Orders were given to seize the position, and a regiment of Ghurkas was detailed to take part in the attack. These are native soldiers, from the foot of the Himalayas, and the army contains no better men. Numbers were shot down by the marksmen on the ridge; a few got across to the shelter at the foot of the cliff; others fell back. Another unsuccessful attempt was made, and the signal was sent to headquarters that the position was too strong for assault. The word came back: "It must be taken!" The Gordon Highlanders, a famous Scottish regiment, had been held in reserve,

and their commanding officer, Colonel Mathias, addressed his men: "Gordons! the General says that position must be taken. The Gordons will take it!" And the Gordons took it. The officers sprang forward into the zone of fire, followed by their men. The pipers, well to the front, struck up a martial Scottish air. They dashed forward regardless of the hail of bullets from the heights above. One of the pipers fell, shot through both ankles, but his music, which inspires and warms the Scottish heart, did not cease. Propped against a boulder, he played lustily, and, to the tune of those warlike notes, the Gordons rushed headlong through all obstacles. Comrades fell around them, but others pressed forward into their places; they reached the narrow path, they scaled the hill, and saw before them the retreating Afridis, who fled down the slopes at the sight of the line of steel. The position was taken and the victors turned to descend, carrying over the rocks the wounded and dying Ghurkas who had fallen in the first attack.

If the rank and file were received with cheers on their return, what welcome awaited the piper? Findlater, the ne'er-do-well of a Scottish village, who was thought to have thrown away all his prospects for life when he enlisted, turning his back on the drudgery of the farm, was now the hero of the day. "Many had died, and there was much glory"; but the man who, crippled and in agony, had sat amidst that storm of bullets, knowing that at any moment his music might be silenced forever, and yet without faltering had made his notes ring over the battle-field, where his fellows were engaged in the excitement of a hand-to-hand struggle, was chosen for the place of highest honor in that regiment of Gordon Highlanders.

Among the medals worn by British soldiers there is occasionally seen a small cross of bronze, known as the Victoria Cross, inscribed with the words, "For Valor." It can be, and it is, won by any soldier, be he private or officer, peasant or peer. Neither civil or military rank affects the bestowal of this mark of honor. It is awarded for conspicuous bravery where many are brave, and it is given by the command of the Sovereign herself. This cross, the highest distinction ever obtained in the British army, is the reward of Findlater, the Scottish piper!

THE COOKING OF WHOLESOME MEALS.

Mrs. Henry Esmond.

Another Good Supper and Some Valuable Hints on How to Cook It—How to Make and Apply Boiled Frosting.

BILL OF FARE FOR SUPPER.
Scalloped Oysters, Baked Potatoes,
Stewed Prunes,
Delicate Cake, with Boiled Frosting,
Tea.

Scalloped Oysters.—Turn 1 pint of large oysters into a cullender and let all the liquor drain off into a bowl. Butter a baking dish and sprinkle the bottom and sides with fine dry bread crumbs. Roll 6 or 8 large soda crackers—not too fine—and put a layer of the crumbs in the bottom of the dish; cover with a layer of oysters from which all pieces of shell have been removed. Sprinkle with salt and a generous supply of pepper, and cover with dabs of butter. Continue in this way until all the oysters are used and the dish is full. There should be a layer of oysters on top. Melt 2 tablespoonfuls of butter, onto which pour 1 cup of fine dry bread crumbs; mix them lightly with a fork and spread over the top of the dish of oysters. Pour 1 cup of milk and the liquor of the oysters over all, and bake in a hot oven for 20 minutes or until the crumbs are brown. Worcestershire sauce or a dash of ground mace is considered quite an improvement by those who like highly-spiced dishes.

Baked Potatoes.—Select potatoes of the same size—not too large. Scrub clean and

pare. Let them lie in cold water 1 or 2 hours. Bake in a hot oven 20 or 30 minutes. Potatoes are composed mainly of water, and as they grow old the water dries up and when pared they have a soft sticky feeling. So, if they are allowed to lie in water for 1, 2, or even 3 hours, they will absorb some of the water and become firm and crisp. Many people like to eat the skin of baked potatoes, but the skin is apt to be gritty and then it is disagreeable; by paring them one is able to eat the inside and the browned skin as well.

Stewed Prunes.—Wash 1 pound of prunes thoroughly and soak them in cold water over night. In the morning put them on the back of the stove (in a stone crock, if you have one). Keep them covered and let them cook slowly for from 1 to 1½ hours. Then add ½ cup of granulated sugar and cook 10 minutes, remove from the fire and cool. Prunes are very healthful and should be kept in the house. They are specially good for children for breakfast.

Delicate Cake.—Cream, ⅓ of a cup of butter, add ¾ of a cup of sugar, then the yolks of 2 eggs, which have been beaten light; put 1½ cups of sifted flour into the sifter and 2 scant teaspoonfuls of baking powder. Sift half of this into the first mixture; then pour in ½ cup of sweet milk. Mix very lightly; then add the remainder of the flour and 1 teaspoonful of vanilla. Last of all, fold in the whites of the eggs, which have been beaten stiff. The flour for cake should be sifted three or four times before it is measured, as the sifting of the flour makes it light, and the lightness of the cake depends a great deal upon the flour. After the flour is added to the cake do not beat it, as beating has the same effect as kneading bread; it makes the cake close-grained and "bready." The flour should be folded in quickly with a spoon.

Pour into an oblong pan which has quite a thick paper, well buttered, in the bottom, and bake in a moderate oven 20 minutes, being careful that it does not get too warm. Frost with a boiled frosting.

Boiled Frosting.—Mix together 1 cup of granulated sugar and ⅓ of a cup of cold water. Boil until the syrup, when dipped into cold water, forms a soft ball. Pour very slowly onto the beaten white of 1 egg. Beat constantly until it is cold; add 1 teaspoonful of vanilla and spread on the cake with a knife which has been dipped in cold water, to prevent its sticking to the frosting. If the icing should turn to sugar or harden before the cake is ready, add 2 tablespoonfuls of boiling water to it and mix thoroughly; then spread it on the cake. It is a good plan to put the cake outdoors for one or two minutes, as this helps to set the frosting.

Tea.—Put 3 teaspoonfuls of tea into a stone teapot; pour onto this about 1 pint of boiling water. Stand the teapot on the back of the stove, where the tea can steep, but not boil. Strain into the teapot used on the table and add 2 or 3 cups of boiling water. Increase or lessen the amount of water according to the strength you like the tea.

NOTICE.

HARVARD SUMMER SCHOOL.

THE Harvard Summer School pamphlet has just been issued, and gives a list of thirty-eight courses. A few of these courses have never been given before, and a few that have been given in previous years are omitted; but the present list embraces the Modern Languages, as well as the Classics, History and Civil Government, Psychology, Pedagogy, Mathematics, and the Sciences. The English Department is represented by three courses in Composition, and a course each in 18th Century Literature, Anglo-Saxon, and Chaucer.

As might be expected, this Summer School at Harvard has attracted numbers of enterprising teachers, and among the students who attended last year are the names of college professors, superintendents of schools, and principals of academies and high schools, who sought the great opportunities which the authorities of the University were offering.

(49) Is there any cooling compound for heated journals and crank-pins? I want something that will cool them without using water.

H. E. S., Eckley, Pa.

Ans.—Water is generally used as the quickest means of cooling off. A good dose of tallow can also be employed. Marine engineers used to put sulphur into a hot bearing, with good effect. Soap or graphite, mixed with oil, can also be tried. Soap is said to be a good thing for the purpose.

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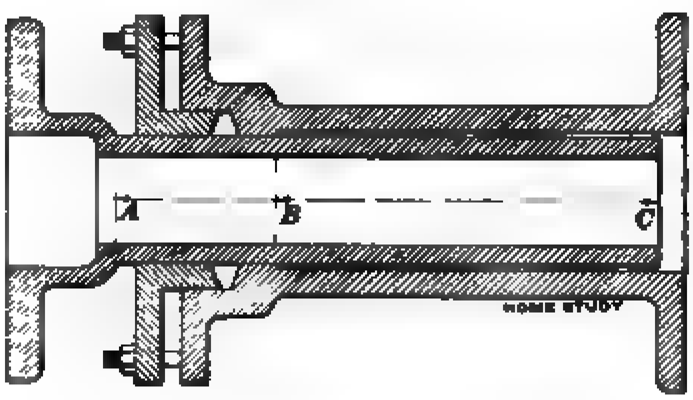
(50) The accompanying sketch shows a 5-inch expansion-joint. I wish to order a new one, but do not know how it ought to be measured. Should the



measure be taken from A to C, or from B to C, the latter being the full allowance for expansion?

O. R., Hecla, Mont.

Ans.—To avoid every possibility of a misunderstanding we advise you to send a complete sketch of the pieces you wish to renew, along with the order.

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(51) Which will show the greater economy for heating purposes, the use of exhaust steam from engine now running condensing, or piping connected direct with live steam? Exhaust can be circulated through system at $1\frac{1}{2}$ pounds back pressure; water for condenser does not cost anything.

H. A. D., Thomaston, Conn.

Ans.—If all the exhaust steam is needed for the heating, it will be economical to use the exhaust for that purpose. If, however, only part of the exhaust steam is required, it will probably be more economical to use a condenser and heat by live steam.

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(52) Please give a good method for clarifying shellac. I want to convert the shellac used by pattern-makers into a colorless transparent liquid.

J. P. C., Palestine, Texas.

Ans.—Shellac, which varies in color from dark amber to an almost pure black, may be bleached by dissolving in a boiling lye of caustic potash and passing chlorine through the solution till all the resin is precipitated. Bleached shellac takes light, delicate shades of color. Average stick shellac contains about 68% of resin, 10% of lac-dye, and 6% of a waxy substance.

(53) I run a milling-machine, the dividing head of which has 3 disks, each with 6 circles of holes, as follows:

Disk 1.	Disk 2.	Disk 3.
15	21	37
16	23	39
17	27	41
18	29	43
19	31	47
20	33	49

To cut 6 teeth I take the 39 circle: 6 turns + 26 holes; or the 18 circle: 6 turns + 12 holes. What general rule can you give me for cutting a gear of a required number of teeth? I have been unable to find any way of cutting 69 teeth and 61 teeth.

J. B. C., Middletown, Pa.

Ans. In cutting 6 teeth you evidently turn the spindle $\frac{1}{6}$ of a revolution for each tooth. Now, when you turn the dividing shaft 6 complete turns + 26 holes on the 39 disk, or + 12 holes on the 18 disk, you evidently turn it $6 + \frac{26}{39} = 6 + \frac{12}{18} = 6\frac{2}{3}$ revolutions, as $\frac{26}{39} = \frac{13 \times 2}{13 \times 3} = \frac{2}{3}$, and $\frac{12}{18} = \frac{6 \times 2}{6 \times 3} = \frac{2}{3}$. The reduction between the dividing shaft and the spindle must, therefore, be $6\frac{2}{3} \times 6 = 40$ times. To cut a gear of x teeth you must, therefore, turn the dividing shaft $\frac{40}{x}$ turns for each tooth. Thus, to cut 25 teeth you must turn the dividing shaft $\frac{40}{25} = 1\frac{15}{25} = 1\frac{3}{5}$ of a revolution. Looking over your list you find that you have one circle of 15 holes, and one of 20, either of which will answer, because $\frac{3}{5}$ may be changed to $\frac{3 \times 3}{5 \times 3} = \frac{9}{15}$, or to $\frac{3 \times 4}{5 \times 4} = \frac{12}{20}$, so that you may use the 15 circle, one turn + 9 holes; or the 20 circle, one turn + 12 holes. To cut 69 teeth the dividing shaft must be turned $\frac{40}{69}$ of a revolution for each tooth, but as this fraction cannot be reduced, and you have no circle of 69 holes, you cannot cut 69 teeth in the ordinary way. However, $\frac{40}{69} = \frac{40}{23 \times 3}$, and $\frac{40}{23 \times 3}$ can be written equal to $\frac{21}{23} - \frac{1}{3}$; for $\frac{21}{23} = \frac{21 \times 3}{23 \times 3} = \frac{63}{69}$; and $\frac{1}{3} = \frac{1 \times 23}{3 \times 23} = \frac{23}{23 \times 3}$, and $\frac{63}{69} - \frac{23}{69} = \frac{40}{69}$. You can, accordingly, cut 69 teeth by first making $\frac{21}{23}$ of a turn, and then $\frac{1}{3}$ of a turn backwards, for each tooth. This you can do by first going 21 holes on the 23 circle, and then backwards 5 holes on the 15 circle, or 6 holes on the 18 circle, or 7 holes on the 21 circle, etc. In a similar manner you can also cut the following gears that cannot be divided by a single turn: 63—69—77—87—93—99. You will find, however, that it is impossible to divide for 61 teeth; for not only is it impossible to reduce the fraction $\frac{40}{61}$, but 61, being a *prime* number, cannot even be written equal to a product of two other numbers, as can all the numbers in the above list. For the same reason you cannot cut the following list. 53—57—59—67—71—

Note.—For conditions to be observed by subscribers wishing to have questions answered in this department, see advertising page IV.

73—79—83—89—91—97. It can be shown that it is also impossible to cut 81 teeth, though 81 is not a prime number.

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(54) I have a 15 H. P. Ruger Manufacturing Co.'s 1896 gas-engine which acts very queerly at times. It uses natural gas. It runs exceedingly well sometimes, but has a habit of suddenly slowing down without any apparent cause, and often stops altogether. Now, where a constant power is necessary, this kind of operation is very unsatisfactory and I shall be glad if you can explain the cause and suggest a remedy. E. F. G., St. Marys, Pa.

ANS.—There are many things that will stop a gas-engine. If it were possible for us to examine the engine it would be an easy matter to locate the trouble and suggest a remedy. Simply knowing that the gas-engine stops gives no clue to the trouble. We give below a few of the principal causes and the proper remedy for each: (1) An irregular pressure in the gas main.—Can usually be helped by putting in a larger rubber bag between the meter and the engine. (2) An exhaust-valve which sticks and does not close.—Regrind the valve and clean the valve-stem. If necessary, stiffen the spring. Use nothing but kerosene to oil the exhaust-valve stem. (3) The gas-valve may have the same defect, and the same remedy applies. (4) Overheating caused by imperfect water-supply or a poor supply of oil to the piston.—The remedy is obvious. Never use an animal oil in a gas-engine. Always get the best mineral oil. (5) Failure of the igniting device.—Ignition-tubes should be blown out once or twice a day and examined occasionally to determine if they are stopped up with carbon (soot). Electric igniters should be tested whenever you are about to start the engine. Keep all your connections bright and don't let your batteries run down. (6) Overloading.—Don't expect a 15 H. P. engine to give more than 20 H. P. (7) Faulty governor.—Your governor may close the gas-valve when the load is very light and fail to open it again when the speed falls. See that the governor works freely.

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(55) Will you please answer the following questions: (a) What kinds of wood are used for patterns, and which is considered the best? (b) Of what does the molding mixture consist? (c) How are complicated castings made? H. S. B., Baltimore, Md.

ANS.—(a) White pine is the best wood of which to make patterns. Bay wood and mahogany are also used for small patterns. Its expense precludes its general use. In Brazil, however, where it is very plentiful, mahogany is much used for small and medium-sized work, such as piston-heads, gears, axle-brasses, etc. When a pattern is to be used over and over again, it is made of metal, either white metal, brass, or cast iron. (b) There are three kinds of molding: *green-sand*, *dry-sand*, and *loam molding*. Ordinary sand is used in the first two cases, though, of course, there are particular kinds which are most suitable for the purpose. The sand is generally mixed with coal- or charcoal-dust, in the proportion of 15 to 1. Green sand is sand in its natural state. For *loam* molding, any natural loam free from alkaline matter will do. A mixture of sand and clay can also be used. For *parting-sand*, either red brick-dust or blast-furnace cinder may be used. Charcoal-dust is used for *facing-sand* in green-sand molding, and coal- or plumbago-dust for the same purpose in dry-sand and loam molding. *Cores* are made of a special kind of sand, which has to be porous as well as adhesive; it must also be free from vegetable matter. Ordinary sand, or powdered blast-furnace cinder, mixed with flour or horse-dung, will answer the purpose. Since cores have to be porous, the sand used should be coarser than molding-sand; the two qualities should, therefore, be kept separate. (c) Just as simple castings are made, i. e., by pouring metal into a sand mold. The patterns often have to be made in several detachable parts, and the mold likewise, but the *principle* is the same as with the simplest casting. You had better subscribe for *The Foundry*, published by The Foundry Publishing Co., Detroit, Michigan.

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(56) Will you be kind enough to inform me what will be the pressure of steam to the square inch inside a boiler 36 inches in diameter and 8 feet long, the gauge-pressure being 10 pounds? Can you give me a rule to find the pressure of any boiler? L. L. de M., Tallahassee, Fla.

ANS.—We do not quite understand your question. If you want to know the *absolute* pressure of steam, that is, the actual pressure per square inch inside the boiler, the pressure, in fact, that would be acting to burst the boiler if the latter were placed in a vacuum, the answer is 24.7 pounds per square inch. Perhaps, however, you want to know the *stress* per square inch of section in the boiler-plates. The maximum stress acts on a longitudinal section of the boiler: the stress which tends to produce transverse rupture is half this. Thus, if the stress on an inch in length of a longitudinal seam is F, that on a similar length of circular-seam is $\frac{1}{2} F$. This is so, independent of the length or diameter of the boiler.

Where p = pressure of steam (above atmosphere) in pounds per square inch;
d = diameter of shell in inches;
t = thickness of plate in inches;
S = stress per square inch,

then, $$S = \frac{p\,d}{2t}.$$

You must remember, however, that the seams are always the weakest part of the boiler. For instance, the strength of the longitudinal seams may be only 75% of that of the solid plate.

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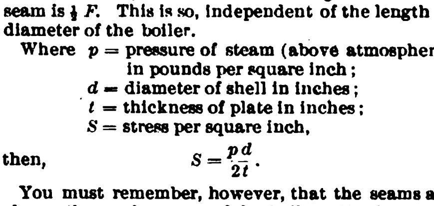
(57) (a) Kindly explain how to calculate the steam-pressure required to raise a safety valve when the weight is set at a given point on the lever. (b) What should be the position of the weight on the lever, in order that the valve shall blow off at a given steam-pressure? (c) Can the smoke from a chimney be carried down and forced through water? (d) Can you tell me of a good book on compound engines that explains how to set up marine engines? J. H. G., St. Louis, Mo.

ANS.—(a) and (b) A reference to the annexed sketch will show that the forces acting on the valve-lever are the weight W, the weight w of the lever,



P—Total upward pressure on valve.

regarded as concentrated at its center of gravity c, and the weight of the valve w_1; all these forces act downwards. Acting upwards is the steam-pressure P on the valve. Remembering that $P = p\,a$, where p = pressure in pounds per square inch, and a = area of valve in square inches, and taking moments about the fulcrum f, we get, $P d = p\,a\,d = w_1 d + w l + W L$;

whence, $$p = \frac{w_1 d + wl + WL}{ad}, \qquad (1)$$

and, $$L = \frac{pad - w_1 d - wl}{W}. \qquad (2)$$

(*c*) We have had no experience in this direction; we can see no reason, however, why it cannot be done. (*d*) Seaton's Marine Engineering is as good a book as we know of. You can procure this of D. Van Nostrand Company, 23 Murray St., New York City. The price is about $6.00.

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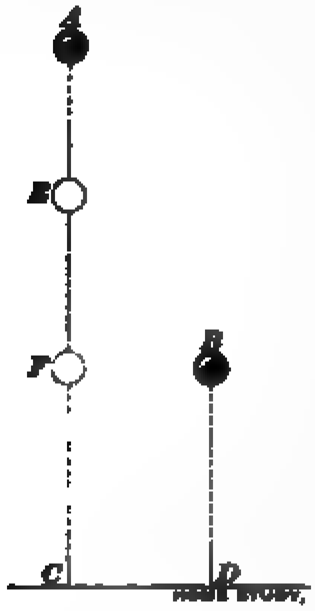
(58) If the attraction of gravitation varies inversely as the square of the distance from the center of the earth, why will a body situated at a great height fall more swiftly than one that starts from a point nearer the earth? R. B., Rochester, N. Y.

ANS.—Consider the body *A* falling from the height *CA*, and the body *B* falling from the height *DB* at the same time. The attraction of gravity on the body *A* being less than on the body *B*, *A* will fall through a less distance than *B*, during the same length of time; so that when *B* reaches the ground at *D*, the body *A* will be at a height *CE* such that *AE* is less than *BD*. The first part of the fall of the body *A* is, therefore, *less rapid* than that of *B*. By the time, however, that *A* reaches the point *F* on a level with the starting-point of *B*, it will have attained considerable velocity, and so falls the remaining distance *FC* much more swiftly than *B* fell the same distance *BD*.



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(59) We have two double engines, supplied by the same steam main. The cylinders of No. 1 engine are 8 inches in diameter, those of No. 2 engine, 5 inches in diameter. No. 1 engine has a 2-inch pipe, No. 2 engine a 1-inch steam-pipe. When we stop No. 1 engine, No. 2 races; when we stop No. 1 engine, No. 2 stops. Would you advise us to put a larger pipe on No. 2 engine? The steam-pressure is 78 pounds gauge. G. L., Saylesville, Pa.

ANS.—Probably the steam main is also too small, and requires to be increased with the pipe of No. 2 engine. However, we fail to see that this change would overcome the rating of No. 2 engine on stopping No. 1, as this is no doubt the fault of the governor of that engine.

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(60) (*a*) Is it advisable, when leaving a boiler for any length of time, to cover the interior surfaces with oil; if so, what kind should be used? (*b*) Are caustic and other sodas injurious to the boiler-plates? (*c*) Is a 2½-inch steam-pipe sufficient for a 7½″ x 10″ engine making 700 revolutions per minute? (*d*) Is there a rule for determining the proper diameter of piston rods given in "The Mechanics' Pocket Memoranda"? (*e*) Would the arrangement shown in accompanying sketch answer for a Prony brake? A. N., Toronto, Ont.

ANS.—(*a*) Yes. Use heavy petroleum-oil, free from tar and wax. Do not use crude oils. In addition to using oil for the purpose mentioned, it is beneficial to do so whenever a boiler has been emptied for repairs, etc. The coating thus formed aids greatly in preventing the formation of scale (*b*) It is acids rather than alkalies that you have to fear in boilers. Acids formed from various vegetable remedies (molasses, barks, etc.) attack the plates injuriously. The presence of soda neutralizes their effect. In fact, generally speaking, sodas form the best remedies for bad water supply, that is, where the water is not purified before being fed into the boiler. Soda is the foundation of nearly all boiler compounds, whatever their name or appearance. (*c*) See answer to question 18 in HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., for August, 1897. (*d*) No. (*e*) Yes, for light powers. You must put a stop though at *S*, to prevent the lever from swinging around.

***

(61) Can you tell me what acid is used for etching on hardened steel? V. O., Pawtucket, R. I.

ANS.—If the surface is clean and free from grease, dilute sulphuric acid or aqua regia (1 part nitric and 3 parts hydrochloric) will do the business.

***

(62) In a tug of war there are 14 men pulling at each end of the rope. Suppose the pull exerted to be one ton by each side, what will be the stress in the center of the rope? The rope is 84 feet long. In an argument over this question, some say it will be two tons, others, only one. What will it be if the one end of the rope is fastened to a tree? A. C. F., Redding, Cal.

ANS.—The pull will, in either case, be just one ton in every section of the *clear* portion of the rope. In the first case, the one side of men may be considered as merely a fastening-point for the rope, to resist the pull exerted on it by the other side of men, and to thus merely take the place of the tree in the second case.

***

(63) Can you give me any data on the strength of malleable iron and steel? All tables give cast iron and wrought steel, but none give the others. W. H. W., Toledo, Ohio.

ANS.—Malleable-iron castings, when properly prepared, are about twice as strong as the original iron castings from which they are made. Good annealed steel castings have an elastic limit of from 22,000 pounds to 25,000 pounds, and an ultimate strength of from 60,000 pounds to 65,000 pounds.

***

(64) I had occasion to cut three screws, 2⅞ inches in diameter by 6 feet long, 4-inch pitch, triple thread, thread ½ inch deep; and after finishing them found the lathe would gain about ¾ inch in 6 feet of thread. The pitch of the lead-screw is 4 per inch. There have been a great many screws of various dimensions cut on this lathe, and by measuring them we found that they all had the same failing Please give me the probable cause of this R. D. M., Tacoma, Wash.

ANS.—The torsional spring of both the lead-screw of a lathe and of the screw being cut always exerts a disturbing influence on the pitch of the latter, but not so much as to account for even a small fraction of the amount in the case quoted, which is equivalent to 1 in 96. The error must, therefore, be due to either the lead-screw being out to nearly that extent, or else to some gear in the train, of between 90 and 100 teeth, being one tooth out.

(65) Please answer the following questions: (*a*) Is there any rule by which I can find the exact distance (in a straight line) between equidistant holes on a given circle, the number of holes being three, four, five, or more? (*b*) What do you mean by stating, on page 76 of your book *Mechanics' Pocket Memoranda*, that "the actual horsepower may be taken as three-fourths of the indicated horsepower"? I always understood that the actual and the indicated horsepower were the same. (*c*) Please give me a formula for cutting and turning bevel-gears. What I want to know is what angle to turn two gears of four pitch, running in each other; also the depth to cut both ends of the tooth, or the angle at which to set the gear on the gear-cutter to get the required depth. Please use four pitch for illustration.

F. W. K., Providence, R. I.

ANS.—(*a*) The table given below, which is easily constructed from the trigonometrical tables, will enable you to figure the required distance for any of the particular number of holes given in the same, the rule being to multiply the diameter of the circle by the number given after the number of holes.

Number of Holes.	Multiplier.	Number of Holes.	Multiplier.
3	.866025	25	.125333
4	.707107	26	.120537
5	.587785	27	.116093
6	.5	28	.111964
7	.433884	29	.108119
8	.382683	30	.104528
9	.34202	31	.101168
10	.309017	32	.098017
11	.281732	33	.095056
12	.258817	34	.092269
13	.246478	35	.089639
14	.222521	36	.087156
15	.207912	38	.082579
16	.19509	40	.078459
17	.183749	[illegible]	.074730
18	.173648	44	.071339
19	.164595	46	.068243
20	.156434	48	.065403
21	.149042	50	.062791
22	.142315	60	.052336
23	.136167	70	.044865
24	.130526	80	.039260

(*b*) By actual horsepower is here meant what is sometimes called the brake horsepower, or effective horsepower, that is, the horsepower that the engine actually transmits to the machinery it drives; while the indicated horsepower is equal to the sum of the actual horsepower and the horsepower the engine expends in overcoming its own frictional resistances. (*c*) Procure a copy of HOME STUDY MAGAZINE for September, 1897. Under "How to lay out gear-teeth" you will find the information you want.

***

(66) I have a 20″ x 42″ Corliss engine in my plant, which is too large for the load at this season, and have advised the management to put in an old automatic engine, 12″ x 18″, until the summer comes on again. We are now putting out not over 25 amperes at 1,040 volts (Wood alternating system), or 26,000 watts, which I estimate to be about 35 H. P.; 60 arc-lamps at 5 amperes at 65 volts, or 26 H. P. The friction of the shafting I estimate at 10 H. P., and thus claim that we are doing under 75 H. P. The management think the engine is not large enough for the work, however. I intend to carry 80 lb. initial pressure and run the engine at a piston-speed of 750 feet per minute. Am I not safe in my calculations?

W. B. R., Cape May City, N. J.

ANS.—We see nothing wrong in your estimate so far as it goes, but you have made no allowance for the loss of power in your electrical generator. If your engine drives only one large generator capable of developing the full power of the engine, the losses in this will be considerable when it is doing light work, and must be considered. If, however, you have two or more smaller generators, and under your present light load use only one of these to its best advantage, then the loss will not be enough to destroy the value of your estimate, as, if you run the engine as you propose, it will easily develop 100 H. P. The best way to go about the matter would be for you to take indicator-diagrams of the Corliss engine, and figure up the *indicated* H. P. developed. We are always glad to give readings of indicator-cards.

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(67) (*a*) At what temperature does aluminum melt? (*b*) How does it compare with silver for hardness? (*c*) Can it be forged? (*d*) Please publish a table giving the inside and outside diameters of standard wrought-iron pipe up to 8 inches in diameter. (*e*) Can back numbers of HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC. be obtained? If so, where? M. S. B., Pleasant Hill, Oregon.

ANS.—(*a*) Different authorities give values for the melting-point of aluminum ranging from 1,112° to 1,160° Fahrenheit. This corresponds to a dull red heat. (*b*) The hardness of nearly pure aluminum is nearly the same as that of silver. Small quantities of impurities increase its hardness a considerable amount. (*c*) Aluminum is ductile and malleable and can be readily forged or rolled at a low temperature. (*d*) The following table includes what you wish:

WROUGHT-IRON WELDED STEAM- AND WATER-PIPE.

DIAMETER.				
Nominal Internal.	Actual External.	Actual Internal.	Thickness.	Number of Threads per Inch of Screw.
Inches.	Inches.	Inches.	Inches.	
1/8	.405	.27	.068	27
1/4	.54	.364	.088	18
3/8	.675	.494	.091	18
1/2	.84	.623	.109	14
3/4	1.05	.824	.113	14
1	1.315	1.048	.134	11½
1¼	1.66	1.38	.14	11½
1½	1.9	1.611	.145	11½
2	2.375	2.067	.154	11½
2½	2.875	2.468	.204	8
3	3.5	3.067	.217	8
3½	4	3.548	.226	8
4	4.5	4.026	.237	8
4½	5	4.508	.246	8
5	5.563	5.045	.259	8
6	6.625	6.065	.28	8
7	7.625	7.023	.301	8
8	8.625	7.982	.322	8
9	9.625	8.937	.344	8
10	10.75	10.019	.366	8

(*e*) Yes. Address a letter to HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., Scranton, Pa.

(68) (*a*) What is the resistance in horsepower of a plane circular disk 100 square feet area of surface, projected horizontally, at the level of the sea in a calm, at a velocity of 20 miles per hour? (*b*) Give an illustration of hydraulic radius, or mean depth.
F. S. B., New York, N. Y.

ANS.—(*a*) If the surface of the disk were at right angles to the direction of motion (Fig 1), the power required to drive it at 20 miles an hour would be 10⅜ horsepower. If, however, the surface were parallel to the direction of motion and the disk was an extremely thin one, the resistance would be inappreciable. It would, however, increase with increasing thickness of the disk. All experiments that have been made with thin planes moving as in Fig. 2,

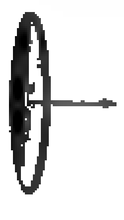


FIG. 1.


FIG. 2.


FIG. 3.

show that the resistance is too small to be accurately measured. (*b*) The hydraulic radius is the quotient of the area of cross-section of the stream divided by the wetted perimeter. In Fig. 3 the wetted perimeter is the arc *a*, *c*, *b*, a semicircumference in this particular case. The area of cross-section of the stream is the area *a o b c*, or in this case half that of the conduit. Hence,

$$\text{hydraulic radius} = \frac{\text{area cross-section}}{\text{wetted perimeter}} = \frac{\frac{1}{2} \times [3.1416 \times (\text{radius of conduit})^2]}{3.1416 \times \text{radius of conduit}} = \frac{\frac{1}{2} \times [3.1416 \times (3)^2]}{3.1416 \times 3} = \tfrac{1}{2} \times 3 = 1\tfrac{1}{2}''.$$

* * *

(69) (*a*) How long will an asphalt pavement last? (*b*) How does a variation in the thickness of the asphalt affect the wear? H. H. B., Chicago, Ill.

ANS. (*a*) Well-constructed asphalt pavement can probably be depended upon to last, under the usual conditions, from 10 to 14 years, if the necessary repairs are made promptly. An asphalt pavement on Cheapside, London, sustained for a period of 19 years a daily traffic of nearly 14,000 vehicles, which probably exceeds the traffic of any American street. The pavement received extensive repairs during this period, however. (*b*) We are unable to say. It may be stated that asphalt pavement does not begin to wear appreciably until its elasticity is overcome by complete and ultimate compression from the traffic, which, under ordinary conditions, will require about two years. At the expiration of this period, the thickness of the pavement will probably be reduced one-fourth, though its weight will be nearly or quite as great as when laid. Wear will then occur substantially the same as upon any compact material, and it is reasonable to suppose that the thickness of the pavement has very little influence upon it, except that a pavement of a certain thickness will, of course, wear longer than a thinner pavement, provided the former is not so thick as to prevent a thorough manipulation of the material in laying. The condition and wear of a pavement will depend largely upon the foundation.

* * *

(70) (*a*) How large a dynamo will a model steam-engine support exerting 0.15 horsepower at 250 revolutions? (*b*) How many 50-volt lamps will this dynamo carry? (*c*) Would it be practicable for storage-batteries to supply lights for an hour or more after the batteries have been charged? (*d*) If this is possible, please give me a description of a storage-battery. J. H., East Orange, N. J.

ANS.—(*a*) A dynamo is measured by the amount of current that it can generate at a certain pressure, the current in *amperes* multiplied by the pressure in *volts* gives the output in *watts*. The output in *watts* divided by 746 gives the output in *horsepower*. The efficiency of such a small machine mentioned could not possibly be more than 66%. If its efficiency is 66%, then it is able to deliver 0.1 electrical horsepower, or 74.6 watts. It is, therefore, a "75-watt generator." (*b*) The candle-power is not mentioned. A 16-candle-power lamp, whether at 50 volts or 120 volts, takes about 50 watts. Your machine is, therefore, good for one and one-half 16-candle-power lamps, or two 10-candle-power. (*c*) Storage-batteries can continue to furnish current until the energy stored in them is exhausted. That is to say, if the current passing from the battery is sufficiently small, the batteries could hold out for years. (*d*) A description may be found in HOME STUDY FOR ELECTRICAL WORKERS for November, 1897. Send 5 cents and we will mail you a copy.

* * *

(71) Referring to Question 564 in the January number of HOME STUDY MAGAZINE, we have been having the same trouble with the self-oiling bearings. We have placed the rings on at *i*, Fig. 1, and the shaft is kept dry, but that is not where the trouble is; the rings that carry the oil up throw some of it against the top of the cap, whence it runs in all directions. The draft from the armature on the one side and the pulley on the other seem to draw this oil out of the cap, and it gets on to the pulley and belt; in fact it is thrown in a spray over everything. We will be glad of any advice you can give on this subject.
F. H. R., Williamsport, Pa.

ANS.—Fix a thick tin apron on, as shown in the accompanying figure. You can fasten it on with screws, but "sweat" it afterwards, so as to keep the oil passing between it and the cap. To prevent the oil dripping from the apron again on to the shaft, roll a bead on it as shown at *a*; the oil will then run in the groove and flow around to the ends, whence it can drop off without touching the shaft. It is probable that a groove, as at *b*, *in the casting* would be equally efficacious.

* * *

(72) (*a*) Will you kindly point out some of the advantages and disadvantages of granite blocks laid in cement, for pavement of streets subject to heavy traffic? (*b*) Name some cities where such pavement is used, and with what success.
P. H. S., St. John, N. B.

ANS.—(*a*) The chief advantage of a pavement consisting of rectangular granite blocks laid, not *in* cement, but upon a foundation of hydraulic cement concrete, is that it is the most durable, and, consequently, the most economical pavement for streets subjected to a heavy and constant traffic. Besides its exceeding durability, it possesses the advantages of being adaptable to all grades and reasonably suited to all classes of traffic, of affording a fair foothold for horses, of requiring but little repair, and yielding but

little dust or mud, and of offering reasonable facility for cleaning. The principal disadvantage of this pavement is the incessant noise produced by the traffic upon it, and the consequent injurious effect that it is claimed to have upon the health of nervous people. It has also the disadvantages of being slippery, if stones of unsuitable quality are used, and of becoming slippery under certain atmospheric conditions, of being very severe upon the legs and hoofs of horses, and of causing considerable jar and discomfort to persons riding over it. (*b*) The ten cities of the United States that in 1890 contained the greatest amount of granite-block pavement are as follows:

New York	140.0 miles.
Boston	62.0 miles.
Brooklyn	55.3 miles.
St. Louis	43.7 miles.
Atlanta	33.0 miles.
Cincinnati	30.0 miles.
Washington	23.2 miles.
Chicago	20.5 miles.
Richmond	16.6 miles.
Albany	16.4 miles.

This pavement, when properly constructed, has always proved satisfactory for heavy traffic, so far as we know.

***

(73) Will you kindly give the names of the various parts of a globe valve, such as is shown by the enclosed blue-print. A sectional view would show the parts better, but I have none at hand.
J. H., Morganza, Pa.

ANS.—Different makers have different names, but we annex a sectional view with reference letters, and a list of names that give a fair idea of the kind of names generally employed by machine manufacturers in designating machine parts.

a—Valve-body.
b—Valve.
c—Valve-nut.
d—Stuffing-box.
e—Gland.
f—Follower-nut.
g—Valve-stem.
h—Hand-wheel

***

(689) Will you kindly give me a formula for ascertaining the safe carrying capacity and the deflection of a half-elliptic steel spring as used on locomotives and as shown in accompanying sketch?
E. C. A., Chicago, Ill.

ANS.—The theoretical form of spring that forms the basis of the one shown in your sketch is represented in Fig. 2. Denoting the thickness and the width of the leaves by t and b, respectively, the number of leaves by n, and the safe working stress on the material by S, then the load applied at the end of the same becomes

$$P = \frac{S}{6} \times \frac{nbt^2}{l} \quad (1)$$

The deflection of the end becomes

$$f = 6\frac{Pl^3}{Enbt^3} = \frac{Sl^2}{Et}, \quad (2)$$

E being the modulus of elasticity of the material. Let us first consider the 3 full leaves of your practical spring separate from the rest. The load that each of these can carry is expressed by the formula $P_1 = \frac{Sbt^2}{6l}$, and the deflection due to this load is $f_1 = 4\frac{P_1 l^3}{Ebt^3}$. Solving the latter with respect to P_1 gives

$$P_1 = \frac{Ebt^3}{4l^3} f_1 \quad (3)$$

Assuming, now, the effective length of each end, or side, of your spring to be 15 inches, the effective width 3¾ inches, the permissible stress $S = 60.000$

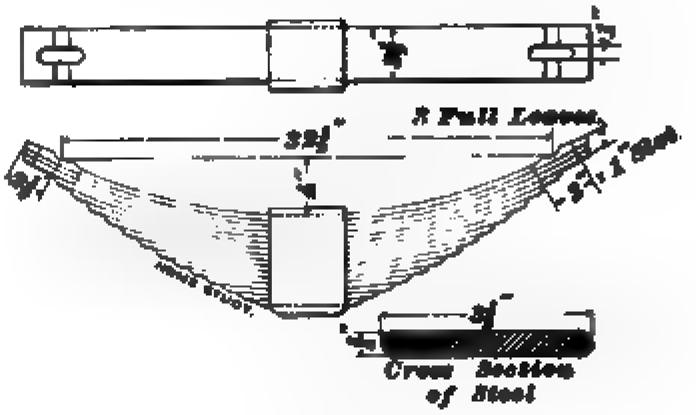


FIG. 1

pounds, and the modulus of elasticity $E = 28,000,000$, we get the load that may be sustained at each end by the 18 graded leaves, from formula (1), to be

$$P = \frac{60,000 \times 13 \times 3\frac{3}{4} \times (\frac{3}{8})^2}{6 \times 15} = 4,113.3 \text{ lb.}$$

The deflection due to this load becomes, from formula (2),

$$f = \frac{60,000 \times 15^2}{28,000,000 \times \frac{3}{8}} = \frac{9}{7} \text{ inches.}$$

Substituting this in formula (3) we further get the load carried by each of the full leaves to be,

$$P = \frac{28,000,000 \times 3\frac{3}{4} \times (\frac{3}{8})^3}{4 \times 15^3} \times \frac{9}{7} = 474.6 \text{ lb.}$$

FIG. 2.

The total load carried by each end thus becomes 4,113.3 + 3 × 474.6 lb. = 5,540 lb., and accordingly by both ends together 2 × 5,540 lb. = 11,080 lb. If we figure the load as if carried by 16 graded leaves we get, from (1),

$$\frac{60,000 \times 16 \times 3\frac{3}{4} \times (\frac{3}{8})^2}{6 \times 15} = 5062.5 \text{ lb.};$$

or, the total 2 × 5,062.5 lb. = 10,125 lb. The deflection is the same in either case. The latter approximation is usually resorted to.

***

(74) Can a message be sent by telegraph-wire through a tunnel? If so why are the telegraph-wires always run over a tunnel instead of through it?
R. S., Ellendale, North Dakota.

ANS.—Telegraph-lines are cheaper of construction, maintenance and operation when run over a tunnel. When run in a tunnel, special wall brackets or overhead supports are required which entail greater cost. The vibration of the trains passing through

the tunnel loosens the fastenings and mechanically deteriorates the structure. The smoke and steam, and the carbon, with the acids and water deposited by these substances, besides acting chemically on the conductor, also conduct small sneak currents.

***

(75) (*a*) What is the initial pressure generated by the explosion of a mixture of 7 parts of air and 1 part of illuminating-gas; the mixture filling a cylinder at atmospheric pressure, but compressed to one-third its volume before ignition? (*b*) Can the pressure thus generated be retained in a closed vessel for any appreciable length of time, say half a minute or more? (*c*) Can you give me simple rules by which I can figure out such problems? (*d*) Is there any text-book that will enlighten me on this subject?

INQUIRER, Reading, Pa.

ANS.—(*a*) The pressure will vary with the kind of gas used. It is usually close to 200 pounds per square inch. (*b*) The fall of pressure depends upon the rapidity with which the heat can escape from the containing vessel. The fall is very rapid, the return to the pressure before ignition taking less than two seconds. The maximum pressure lasts but a few hundredths of a second in a vessel that has no lagging. (*c*) No simple rules can be given. (*d*) "The Gas- and Oil-Engine," D. Clerk. Chap. VI.

***

(76) (*a*) What is the unit of hardness? (*b*) What are the dimensions and composition of the standard candle? (*c*) I have noticed that, when the temperature is below 32° F., concrete is mixed with lime: does not this interfere with the setting of the concrete? (*d*) Could lime-water be mixed in this way? How much salt should be used?

J. A. V., New York City.

ANS.—(*a*) There is, properly speaking, no unit of hardness, but there is a *scale* of hardness. This consists of (1) talc, (2) gypsum, (3) calcite, (4) fluorite (fluor-spar), (5) apatite, (6) orthoclase, (7) quartz, (8) topaz, (9) sapphire, (10) diamond. (*b*) The standard candle is a candle of spermaceti, which, burning 120 grains of spermaceti, is used as the standard of gas-light—the amount of light given by the gas, burning from a jet at the rate of 5 cubic feet per hour, being, by means of a photometer, compared with it. There are no definite proportions as long as the candle is so made that it burns *exactly* 120 grains per hour. Spermaceti is the solid portion of an oil which fills the cranial sinuses, or bone cavities, of the sperm-whale. (*c*) Concrete is often made when the thermometer is below 32° with 3 parts Rosendale cement to 1 of lime. The addition of lime to the cement is supposed to keep it from freezing. The *Portland* cements are not injured by freezing. (*d*) Lime-and-cement mortar is made of 1 part cement, 1 part lime, and 3 parts sand: this is used in foundation-work. The use of salt is not recommended in mixing mortar, as it causes the mortar to set very slowly. If it is used, 1 pound of salt to 18 gallons of water, with the thermometer at 32° F., and 2 ounces additional of salt for each degree colder, is the general rule.

***

(77) To one corner of a barn 50 feet square is fastened a rope 200 feet long, at the end of which is a cow. What area can the animal graze over?

J. McG., New York City.

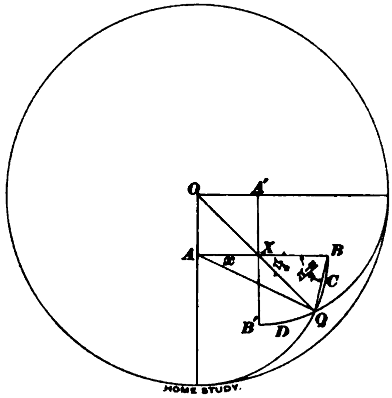
ANS.—The solution you sent us is wrong, as you will see from the following: Let O be the corner to which the cow is fastened; then the cow can graze over $\frac{3}{4}$ of the circle whose center is O, $\frac{1}{4}$ of the circle whose center is A, and $\frac{1}{4}$ of the circle whose center is A'. But these last two quarter-circles overlap and have the space $XBCQDB'$ common. Hence, we must find area of the space $XBCQDB'$, which we shall denote by a. The line XQ bisects the space a. Hence,

$$\frac{a}{2} = XBCQ = \text{sector } (ABCQ) - \text{triangle } (AXQ) -$$

$$\tfrac{1}{2}(AB)^2\left\{\frac{\pi x^\circ}{180} - \tfrac{1}{2}\,AX \times AQ \times \sin x\right\}.$$

Referring to formula (1) in answer to Question 20 published in the February, 1898, HOME STUDY MAGAZINE, we get

$$XB\cot x - AX\cot\left(\frac{\pi - x}{2}\right) = AB\cot\frac{\pi}{4}.$$



Therefore, $\qquad 100\cot x - 50\tan\frac{x}{2} = 150.$

Therefore, $\qquad \dfrac{2\left(1 - \tan^2\frac{x}{2}\right)}{2\tan\frac{x}{2}} - \tan\frac{x}{2} = 3.$

Solving, $\tan\frac{x}{2} = \frac{\sqrt{17} - 3}{4}$, or, $x^\circ = 31^\circ\ 22'\ 1\frac{1}{8}''$; whence, $a = 8413.9$ square feet. Hence, the space grazed over by the cow is 121,177.1 square feet.

***

(78) Can you tell me of a good book on the solution of grade-crossings in cities? If possible, tell me where I can get the book, and the price.

M. C. H., Washington, D. C.

ANS.—We know of no book on this special branch of street-building; but the subject is well treated in such works as Gillmore's "Roads, Streets, and Pavements" (Van Nostrand, \$2.00), Spalding's "Roads and Pavements" (J. Wiley, \$2.00), and Law and Clark's "Roads and Streets" (Van Nostrand, \$1.80).

***

(79) Can you give me the address of the patentee or the parties who control the "Rites" engine-governor?

A. B. C., Chattanooga, Tenn.

ANS.—Write to F. M. Rites, M. E., Ithaca, N. Y.

***

(80) (*a*) If I am putting up a weir of suitable stone to divert some water in a good-sized stream, and have in the vicinity of my work limestone of hydraulic property, should I use sand with it, and in what proportion? (*b*) Supposing I were to use common lime, and point deeply with hydraulic lime, or cement mixed with a proportion of sand, or cement without sand, would this be safe, seeing that common lime requires air to set it? (*c*) What is the use of using sand with limes and cements, except to economize? Why would it not be better to use the lime only?

F. O., Cape Town, South Africa.

ANS.—(*a*) Use clean, sharp sand with the cement in about the proportion of 2 parts sand to 1 part well-burned and finely ground hydraulic cement; point with neat hydraulic cement. The best proportion

of sand to cement will depend somewhat upon the quality of the cement. (*b*) We are unable to say whether it would be safe to use common lime and point with hydraulic cement. If pointed deeply and thoroughly it is possible that the result might be satisfactory, but we would prefer to use the hydraulic cement-mortar. (*c*) A mortar produced by mixing sand with cement will always be weaker than the cement itself; the same is true of lime-mortar. We know of no reason for using the sand except on the score of economy. Mortar consisting of hydraulic cement and sand mixed in proper proportions will, however, become stronger than ordinary stone; consequently, there is usually no necessity for using a stronger mortar

***

(81) (*a*) Please give the method of generating electrozone on a small scale. (*b*) Can I use either a continuous or alternating current and what voltage should I use? (*c*) What is the solution composed of? (*d*) How can it be obtained at a pressure?

J. A. B., Eureka, Utah.

ANS.—(*a*) Electrozone is produced by passing a current of electricity through sea-water. The positive electrode is made of some substance that will not be decomposed by the electrolytic action. Copper coated with platinum is generally used for the positive, while for the negative electrode carbon is used. (*b*) Direct current only at 5 volts pressure. (*c*) As made from sea-water, electrozone contains a one-per-cent. solution of chloride of lime. (*d*) By being compressed by mechanical means.

***

(82) What would be the difference in strength between an ordinary round chain link and an $ hook made of the same-sized iron? J. B., New York City.

ANS.—From the annexed sketches, on which are given formulas for the carrying capacity of the two links for a stress *S* within the elastic limit of the material, you will see that the continuous link is just four times stronger than the $ hook, irrespective of diameter and the strength of the material. We cannot here go into the derivation of these formulas, however. The *ultimate* strength of the link will be still greater by a considerable amount.

***

(83) Is there any way of renewing tracing-cloth which has been damaged by spots of water?

W. C., Cascade Locks, Oregon.

ANS.—We know of no way of completely restoring the original surface to the cloth: but, by first putting coal-oil on the spots and ironing them over, you can make the surface transparent enough for blue-printing, and by then polishing it with soapstone (tailors' chalk) you can also draw on it without the ink spreading.

***

(84) (*a*) In a series of 50 arc-lamps "Thompson-Houston's" system, the current emanates from a 50-arc lighter: Please explain why the first lamp, which is nearest the generator, is not fifty times brighter than the last one in the series? (*b*) Lamps are registered at 50 volts; the aggregate voltage for 50 lamps is therefore $50 \times 50 = 2{,}500$ volts. How does the adding or cutting-out of a lamp in a series change the voltage of the generator? (*c*) What automatic arrangement governs the voltage of a lamp to keep it at 50 when a current of 2,500 volts is passing over the main wire?

T. T. V., Frackville, Pa.

ANS.—(*a*) The current passing through each lamp is the same: the total voltage is subdivided among all the lamps of the circuit. The resistance of each lamp is practically constant, say 5.4 ohms, and since the current is about 9 amperes, the E. M. F across the lamp-terminals will be in the neighborhood of 50 volts. (*b*) An arc-light machine is provided with a regulator which maintains a constant current, whatever the number of lamps on the circuit. (*c*) A series-and a shunt-solenoid, which so operate the cores and attached mechanism as to maintain a constant air gap, or arc.

***

(85) (*a*) Please explain the principle of the air-thermometer mentioned and illustrated on page 88 of HOME STUDY MAGAZINE for May, 1896. (*b*) In one of my dictionaries, under *axiom* is given "The first axioms of Euclid are ." What does the word Euclid mean? H. S. H., Stroudsburg, Pa.

ANS.—(*a*) The air-thermometer consists of a tube with a bulb at one end. The bulb and a portion of the tube is filled with air, and above the air in the neck of the tube are a colored liquid. Heat expands the air in the bulb, and the expansion is shown by a movement of the liquid The air-thermometer has the advantage that a slight change of temperature gives a considerable movement of the liquid; it cannot, however, give the temperature directly, and is therefore used only in accurate physical experiments. (*b*) Euclid was a Greek geometer who lived about 300 B. C. He was the first to develop the science of geometry in its present form.

***

(86). (*a*) What is meant by a three-phase motor? (*b*) If a 3-inch steam-pipe 50 feet long is connected with a 1-inch pipe 50 feet long, will there be as much pressure at a distance of 100 feet from the boiler as there is 50 feet from the boiler, if the pipes are covered with asbestos? L. B. D., Jonesville, Wis.

ANS.—(*a*) A three-phase motor is one especially constructed for a three-phase circuit. The distinguishing feature of a three-phase circuit is that it is made up of three conductors, through each of which an alternating current is passing. The amount of current passing in one direction in the circuit is equal to the amount passing in the opposite direction: that is, the amount of current in one wire equals the inverse sum of the currents in the other two wires. As a matter of fact, the alternating currents are so generated that this maximum, or summation, current passes from one wire to the second wire, onto the third wire, back to the first wire and so on, this change taking place gradually, but at a speed of about 125 complete cycles per second. It is this rotation that is taken advantage of and used in the three-phase motor. (*b*) Yes: unless steam is being drawn from the 3-inch pipe, when there will be considerable *drop* in the pressure in the 1-inch pipe.

(87) I wish to make a drawing of a pair of cone pulleys to connect shafts that are 8 feet apart from center to center. The countershaft makes 56 revolutions per minute. The driven shaft must have a maximum speed of 224 revolutions and a minimum of 28 revolutions per minute. The cones must have six steps. The largest pulley that can be used upon the driven shaft is 12 inches diameter, and the smallest 3 inches: the face of each step to be 3 inches. Will you kindly make the drawing and explain the necessary calculations. A. J. M., Ann Arbor, Mich.

ANS.—In Fig. 1 we show the pulleys as they would ordinarily be made, with their steps forming perfect cones. These cones would be correct, so far as the tension of the belt goes, if *crossed*. Fig. 2 shows the pulleys as they ought to be made if the belt is to be open. However, to explain all the calculations that have been made would occupy too much space for these columns; in the near future the subject will be treated as an article in this magazine. In both figures you will find the number of revolutions corresponding to a step marked directly under it, and you will see that the maximum is the required 224, and the minimum the required 28, in both cases.

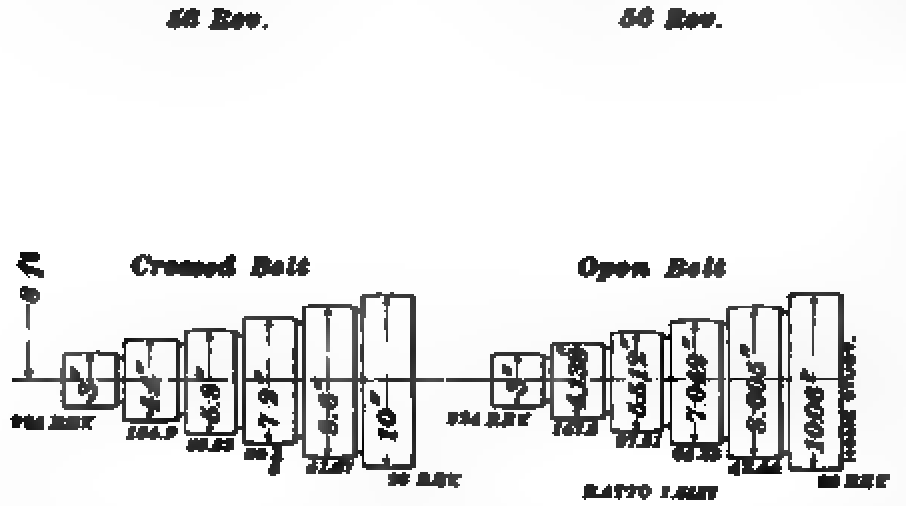


FIG. 1. FIG. 2.

You will, however, also notice that the intermediate speeds are somewhat different in the two cases. This is because *straight* cone pulleys give speeds that are only approximately in a geometrical progression, while we have taken the trouble to arrange the speeds of the pulleys in Fig. 2 in an exact geometrical progression, which is the ideal arrangement. We have, however, made no allowance for either the slip or the thickness of the belt, which might have been done, but which is usually an unnecessary refinement.

***

(88) In reading up the Edison three-wire system for incandescent lighting, I find one author says the saving over the two-wire system in copper is five-eighths, while another author says it is 25 per cent. What *is* the saving and why is there a saving? E. C. J., Titusville, Pa.

ANS.—If the size of the wire is determined by its maximum carrying capacity, the outside mains of the three-wire system are just one-half the size of the mains of a two-wire system; and, in a three-wire system, the neutral wire is generally taken one-half the size of the outside mains. In this case, the three-wire system requires but five-eighths the material of a two-wire system. If, however, the current is to be transmitted some distance and the size of the wire is determined by a certain predetermined line-loss, and the neutral of the three-wire system is allowed to be equal sectional area to one of the outside mains, then the three-wire system requires but three-eighths of the copper used on a two-wire system. This can be proved by substituting in the formula: *size of wire in circular mils* = (*10.8* × *electrical distance in feet* × *current in amperes*) ÷ *drop in volts*.

(89) What are the best books for self-study in higher mathematics, such as analytical geometry and the calculus? O. P., Brooklyn, N. Y.

ANS.—There are no books on these subjects that are well-adapted to self-instruction. We should advise you to purchase Olney's University Algebra ($1.44), Olney's Elements of Trigonometry ($1.12), and Olney's General Geometry and Calculus ($1.80); the last-named work treats on both analytical geometry and calculus, and contains more information that is of real value to a practical man than any other text-book of which we are aware. The first two books are recommended because there are frequent references to them in the General Geometry and Calculus, and because of their intrinsic worth.

***

(90) I would like your advice regarding the use of anchors, clamps, etc. for securing thin, marble, ashlar facing to brick backing. (*a*) Do you think that if such members are galvanized and painted, the face of the marble will be safe from the possibility of rust stains striking through the ashlar? (*b*) Are galvanized copper anchors, etc. considered better than iron for the above purpose? F. H. R., St. Paul, Minn.

ANS.—(*a*) It is generally considered that galvanizing iron anchors prevents rust from streaking stone ashlar. Another good plan is to dip the anchors or clamps in hot asphalt: this is more desirable than painting. (*b*) Copper does not rust, and is therefore a good material for ties or clamps. It is considerably more expensive than iron, but is usually specified for first-class work.

***

(91) I am anxious to know of a good acid-dip for brass composed of copper 88, tin 10, and zinc 2. I have tried sulphuric and nitric acid in various proportions, with and without salt, but the mixture that I have found very suitable for yellow brass is no good for brass that is rich in copper, but only imparts a gray surface to it. R. J. K., Cleveland, O.

ANS.—The following acid-dip has been recommended to us, but as we have not tried it personally, we cannot guarantee that it will work satisfactorily:

Sulphuric acid	12 pounds;
Nitric acid	1 pint;
Nitre	4 pounds;
Soot	2 handfuls;
Brimstone	2 ounces.

Pulverize the brimstone and soak it in water an hour. Add the nitric acid last.

***

(92) (*a*) How is acetylene gas made? (*b*) How are Bunsen burners made, and how do they act? G. H., Suncook, N. H.

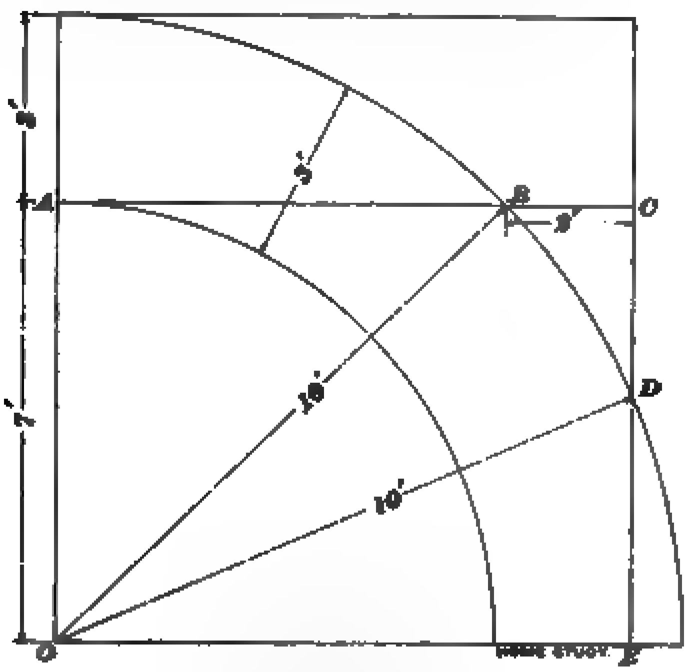
ANS.—We suppose you mean acetylene (C_2H_2), this gas may be prepared by the direct union of carbon and hydrogen at high temperature. The most convenient method of thus preparing the gas is by passing a current of electricity, from a powerful voltaic battery, through two electrodes of carbon enclosed in a glass flask containing hydrogen. (*b*) The smokeless gas-burners employed in laboratories, etc. exhibit the result of mixing the gas with a considerable proportion of air before burning it; the luminous part of the flame then entirely disappears with great augmentation of the temperature of the flame, since carbon is burned simultaneously with the hydrogen. The most effective burner constructed in this way is the Bunsen burner. It consists of a narrow tube of cast iron, through which the gas is conveyed into a wide tube, at the base of which there

are two or more large holes for the admission of air. When a good supply of gas is turned on, a quantity of air, about twice the volume of the gas, is drawn in through the lower apertures and the mixture of air and gas may be kindled at the orifice of the wide tube.

***

(93) I would like a purely theoretical demonstration of the following problem: Referring to enclosed sketch, what is the distance $D C$ to the curved rail at right angles to the straight rail 2 feet from the point of frog? A. R., Scottdale, Pa.

ANS.—In the right triangle $O A B$, we have,



$$A B = \sqrt{O B^2 - O A^2} = \sqrt{51}.$$

Therefore, $E C = A B + B C = \sqrt{51} + 2.$

Now, $O E$ is equal to $B C$. In the right triangle $O D E$,

$$E D = \sqrt{O D^2 - O E^2} = \sqrt{O D^2 - A C^2} =$$

$$\sqrt{10^2 - (\sqrt{51} + 2)^2} = 4.054 \text{ feet.}$$

and $D C = E C - E D = 2.946$ feet.

***

(94) Would there be any saving in equalizing a simple compound engine whose cylinders are 20 inches and 30 inches diameter, respectively, and stroke 48 inches, the engine exhausting against the atmosphere? E. F. S., Salt Lake, Utah

ANS.—By "simple," we suppose you mean an *ordinary* compound engine. Your question is not very clearly expressed. It is certainly desirable to so adjust the cut-off in the high-pressure cylinder as to equalize the amounts of work done in that and the low-pressure cylinder. Is that what you mean?

***

(95) (*a*) Please give receipt for nickel-plating solution. (*b*) Can you tell me of an alloy that will not tarnish nor corrode, nor leave a brassy taste in the mouth and that is nearly or quite acid-proof? P. H. K., Rochester, N. Y.

ANS.—(*a*) One part of nickel salt—best nickel ammonium sulphate $NiSO_4(NH_4)_2SO_4\,6\,H_2O$—in 18 to 20 parts of distilled water can be recommended. (*b*) No; the composition of alloys is the result of practical experiments rather than the application of chemical principles. We suppose a manufacturer of musical instruments such as trumpets, bugles, etc. can give you readily the desired alloy composition.

***

(96) Is there any way in which I can melt small pieces of platinum so that they will run together? I think it could be done under the positive carbon of an arc-lamp, but is there no other way? The weight of the platinum would not amount to more than several grains. W. B. C., Toronto, Ont.

ANS.—Platinum may be melted by means of the oxyhydrogen blowpipe in furnaces specially prepared for this purpose. We would advise you to get a piece of platinum of the desired size from some dealer in chemical supplies; the price is about 50 cents per gram.

***

(97) I send you samples of rock taken from a rock that crops out of a bluff in two ledges about 1 foot thick, running back under the surface at depths of 4 and 10 feet, respectively. Kindly inform me as to the nature and value of the rock. C. K. H., Laurel, S. C.

ANS.—A fine-grained pebble or sand conglomerate, heavily stained by iron. Cannot tell whether it contains gold or silver without an assay.

***

(98) I have a piece of quartz crystal as it came from the feldspar quarry. It is discolored with a substance that looks like iron rust. Will you please tell me how to clean it? E. E. H., Richmond, Maine.

ANS.—If rust is outside, it will dissolve off with hydrochloric acid. If it is in the crystal, however, it cannot be gotten out.

***

(99) How can I line a cast-iron bottle so that it will resist the action of sulphuric acid? Is lead the only material to use? How thick should the lining be? W. McC., Brandon, Mass.

ANS.—The bottle should be lined with lead. The thickness of the lining depends upon the size of the bottle; $\frac{1}{8}$ to $\frac{1}{4}$ of an inch will be sufficient.

***

(100) Will you kindly give the formula that will enable me to solve the following problem: What is the diameter of the hole that must be bored through a 6-inch sphere in order to remove half the contents of the sphere? Kindly work out the example in detail. L. S. B., New York, N. Y.

ANS.—The whole volume removed consists of two equal circular segments S and S, and a cylinder C. We have

$$S = \frac{\pi r^3}{3}(2 - 3\cos x + \cos^3 x),$$

$$C = 2\pi r^3(\cos x - \cos^3 x).$$

Therefore, $$2S + C = \frac{2\pi r^3}{3}(2 - 2\cos^3 x).$$

To remove $\left(\frac{1}{n}\right)$ part of the sphere we have,

$$2S + C = \frac{1}{n}(\text{volume of sphere}).$$

Therefore,

$$2S + C = \frac{4}{3n}\pi r^3,$$

or, $$\frac{2\pi r^3}{3}(2 - 2\cos^3 x) = \frac{4}{3n}\pi r^3,$$

whence,

$$\cos^3 x = 1 - \frac{1}{n}.$$

To remove half the sphere, make $n = 2$,

then, $$\cos x = \frac{1}{\sqrt[3]{2}},$$

or, $x = 37°\ 28'\ 2\frac{1}{2}''$, and $y = r \sin x = .6083\,r$.

Hence, if D is the diameter of the sphere and d is the diameter of the hole, we have $d = 2y = .6083\,D$. For 6-inch sphere this gives, $d = 2.4498$ inches.

(101) In the accompanying sketch $A\ B$ is a vertical post, $A\ D$ is a horizontal beam of wood of uniform cross-section, 6 feet long and weighing 50 pounds, s is a sheave and the distance from its center to the center line of the beam $A\ D$ is 3 feet. The rope is attached to the center of the beam $A\ D$. What weight W will just sustain $A\ D$ in a horizontal position?
A. J. J., Lakewood, N. J.

ANS.—You have neglected to give either the radius R of the sheave, or its horizontal location. Neglecting the friction of the sheave, the tension T on the rope will be equal to the weight W. The vertical component V of this tension must evidently be equal to the weight L of the beam. But we have $V = T \sin x$, and accordingly, also, $L = W \sin x$, or $W = \frac{L}{\sin x}$. Angle x = angle $B\ C\ A$ + angle $B\ C\ D$, and to determine these angles we have $\tan B\ C\ A = \frac{A\ B}{A\ C} = \frac{h}{a}$; and $\tan B\ C\ D = \frac{B\ D}{B\ C} = \frac{R}{\sqrt{h^2 + a^2}}$.

* * *

(102) How many pounds of water at 180° F. will just condense 1 pound of steam at 213° F.? Please give the formula you use in working out the answer.
D. M., New York, N. Y.

ANS.—Let w = weight of water required; q = number of heat units contained in a pound of water at the given temperature above water at 32°; q_1 = heat units above 32° contained in a pound of water at temperature of steam; h = latent heat of steam at given temperature. Then the formula is $w = \frac{h}{q_1 - q}$. In the question, the h of steam at 213° is 965 B. T. U. q_1 = 181.9 B. T. U. and q = 148.5 B. T. U. (These values must be obtained from the steam table.) Then,

$$w = \frac{965}{181.9 - 148.5} = 28.9 \text{ pounds.}$$

* * *

(103) By what formula can I determine the thickness of the sides and bottom of an open rectangular tank to contain a given number of gallons of water?
C. F. C., Philadelphia, Pa.

ANS.—The bottom of the tank is a rectangular plate uniformly loaded with p pounds per square inch, where p is .43 of the depth of the water in feet. Letting a and b represent the length and breadth of the bottom; t, its thickness; and S, the allowable working stress in the material, the formula for thickness is, $t = \frac{3}{2} a\ b \sqrt{\frac{p}{S(a^2 + b^2)}}$. The sides are not uniformly loaded, but the same formula may be applied, using $\frac{1}{2} p$ instead of p as the pressure per square inch.

* * *

(104) Please answer the following questions: (*a*) Enclosed sketch, Fig. 1, shows the high-pressure valve of a high-speed tandem compound engine. As will be seen, the valve has no inside lap on one end, and has negative inside lap on the other. I wish to know

FIG. 1.

what defect in the valve-motion this arrangement is supposed to offset, and if there would be any other way of doing the same thing. The accompanying diagram, Fig. 2, shows high compression, but in my opinion there is also another defect which is worse. (*b*) The engine in question was made by J. H. McEwen, Ridgeway, Pa. I suppose you are familiar

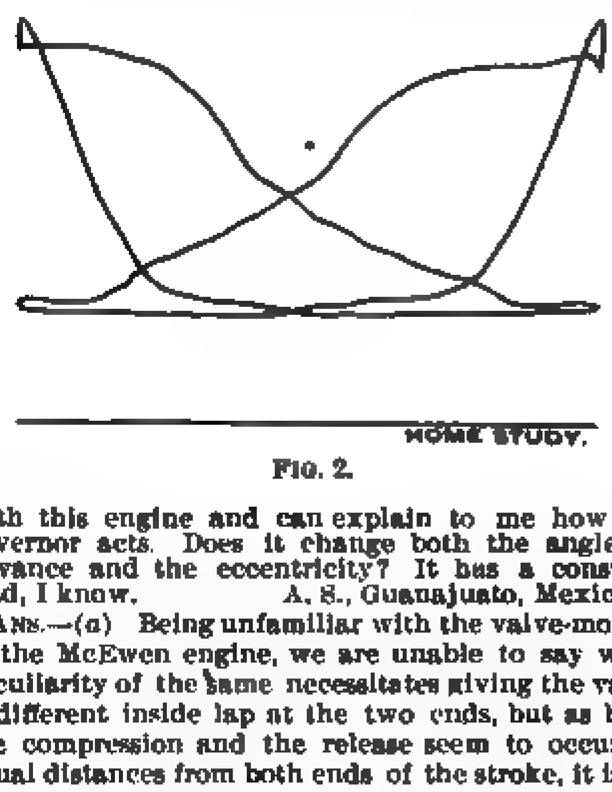


FIG. 2.

with this engine and can explain to me how its governor acts. Does it change both the angle of advance and the eccentricity? It has a constant lead, I know.
A. S., Guanajuato, Mexico.

ANS.—(*a*) Being unfamiliar with the valve-motion of the McEwen engine, we are unable to say what peculiarity of the same necessitates giving the valve a different inside lap at the two ends, but as both the compression and the release seem to occur at equal distances from both ends of the stroke, it is no doubt done because of some peculiarity of the valve-motion. Both release and compression begin rather too early, and the point of cut-off is not equal at the two ends, but otherwise we can see no defect in the diagram. (*b*) All we know about the McEwen governor is that it enjoys a good reputation for close regulation.

* * *

(105) (*a*) Is there any method of making prints having black lines on white ground? If so, will you please explain it. (*b*) Can you recommend a good book on wood-finishing?
C. A. C., Ashley, Pa.

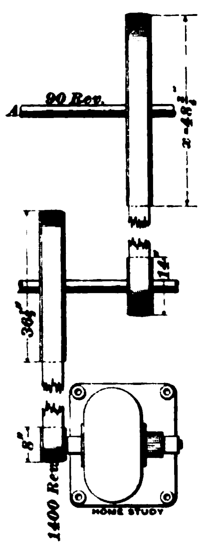
ANS.—To obtain prints from tracings which will have black lines on a white ground, prepare the following solution: Gelatin, or gum arabic, 15 parts; sulphate of iron, 6 parts; chloride of sodium,

9 parts: gallic acid, 2 parts; perchloride of iron, 15 parts; water, 110 parts. Spread this over the paper with a sponge, or brush, in a dark or dimly lighted room, and when dry expose the sheet under the tracing to strong sunlight for 10 minutes, or until the paper bleaches out white, the lines of the drawing alone remaining yellow; then remove and place in a cold-water bath. Sponge the print thoroughly to cleanse it, and if the paper is strong enough scrub it with a hard brush. The lines will turn black, but the ground will remain white. Any yellowness or muddiness in the ground may be removed by immersing the print in a very weak solution of hydrochloric acid. (*b*) The French Polisher's Manual can be obtained through The Technical Supply Co., Scranton, Pa.

***

(106) I have a dynamo with an 8-inch pulley that has to run 1,400 revolutions, and I want to drive from a shaft making 90 revolutions by putting in an old jack-shaft that has two pulleys of 36¼ inches and 14 inches diameter, respectively. I am at a loss to know the diameter of the pulley required on the main driving-shaft *A*.

G. C., Pittsburg, Pa.



ANS.—Making no allowance for the thickness of the belts, but allowing 2% of slip for each drive, this problem is worked out as follows: Speed of jack-shaft equals $1{,}400 \times \frac{8}{36\frac{1}{4}} \times 1.02 = 313.58$ revolutions. Diameter of pulley required for shaft *A* equals $14 \times \frac{313.58}{90} \times 1.02 = 49\frac{3}{4}$ inches.

***

(107) (*a*) How can I find the size of radiator required to heat an office-room 21 ft. × 25 ft. × 14 ft. high? The room has two doors, each 3 ft. 6 in. × 7 ft., and five windows, each about 3 ft. 6 in. × 6 ft. We will carry 100 pounds boiler-pressure. I intend to put a pressure-regulating valve between the main steam-line and the radiator; temperature in office to be about 70° F. (*b*) Who is the inventor of skylight glass which has wire netting imbedded in it, and where can I obtain the glass?

F. C. O., Pittsburg, Pa.

ANS.—(*a*) Since you propose to use a pressure-regulator, we presume that you intend to reduce the boiler-pressure down to about 3 or 5 pounds at the radiators; and consequently we will compute the radiating surface required, by a rule commonly used for low-pressure heating work. Rule: Multiply the number of square feet of exposed glass surface and its equivalent in exposed wall surface, etc. by .5; the result will be the number of square feet of ordinary direct radiation required to counteract all loss of heat by conduction through the walls and windows. It is customary to figure outside doors as exposed glass surface, and walls are usually converted into glass equivalents by dividing the exposed wall surface by 4, 5, 6, 7, 8, 9, or 10, according to the kind of material used and the manner in which it is built. On top of all this we must make allowance for the location of the building—whether sheltered or exposed to strong winds—and we must not forget to make due allowance for badly fitting windows, loose boarding, etc., all of which can only be determined by a survey of the premises. Assuming that your office has only two walls exposed to the weather, and that the five windows and two doors are in these walls; also assuming that the floor, ceiling, and inside walls are warm; also assuming that the exposed walls are of ordinary construction; then the amount of direct radiation required will be about as follows: exposed glass surface $= 3.5 \times 6 \times 5 = 105$ sq. ft.; door surface (equivalent to glass) $= 3.5 \times 7 \times 2 = 49$ sq. ft.; glass equivalent in exposed wall surface, allowing a ratio of 6 to 1, equals

$$\frac{14\,(25+21) - (105+49)}{6} = 82 \text{ sq. ft., nearly.}$$

$$\text{Radiation} = .5(105 + 49 + 82) = 118 \text{ sq. ft.}$$

It is customary to allow from 25 to 50 per cent. for air leakage. If we allow 30 per cent in your case, then the total amount of direct radiation you require will be 118 + 36 = 154 square feet. We would advise you to divide the total amount of radiation into at least 3 radiators, then you will be in a position to shut off the heat according to the severity of the weather. If you use cast-iron radiators we would advise you to place a safety valve, set to blow off at 10 pounds, on the radiator-side of the regulator. (*b*) We do not know who invented the skylight glass referred to. It is manufactured by the Mississippi Wire Glass Company, St. Louis, Mo.; they have branch-offices in all cities.

***

(108) Please explain the process of making "tin-type" photographs.

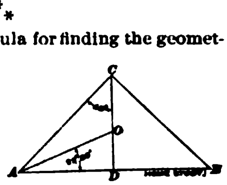
J. H. D., Colorado Springs, Colo.

ANS.—A piece of tin, one side of which is coated with enamel, is spread with a thin film of collodion, in which bromide and iodide of potash or ammonia are dissolved. The tin plate is then immersed in a solution of nitrate of silver until the bromides on the surface unite with the silver and form a white coating on the plate of bromo-iodide of silver. The plate is then exposed in the camera while still wet, and developed by pouring over its surface a solution of sulphate of iron. After development, the plate is washed and immersed in a solution of hyposulphite of soda, washed again, dried, and varnished. Tin-type plates are also manufactured in the same manner as dry plates, but are not so generally used, as the dry process is more expensive than the wet and does not yield as satisfactory results. The directions for working the dry plates accompany each package.

***

(109) Please give a formula for finding the geometrical center of an equal-legged right-angled triangle, that is, for finding the center of the inscribed circle.

W. H. W., Jr., Newport News, Va.



ANS.—Since the triangle is isosceles, *CD*, the bisector of the vertical angle, bisects the base perpendicularly;

hence, $$A\,D = \frac{A\,B}{2}.$$

Then, $$O\,D = A\,D \tan 22° 30' = \frac{A\,B}{2} \tan 22° 30'.$$

Now, $$\tan 2x = \frac{2 \tan x}{1 - \tan^2 x};$$

therefore, $$\frac{2 \tan 22° 30'}{1 - \tan^2 22° 30'} = \tan 45° = 1.$$

Solving, $$\tan 22° 30' = \sqrt{2} - 1.$$

Hence, $$O\,D = \frac{A\,B}{2}(\sqrt{2} - 1).$$

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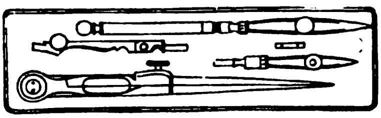

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PLANE MOTION.

George A. Goodenough.

HOW A MOTION IS DETERMINED—EVERY PLANE MOTION IS A ROTATION—INSTANTANEOUS AND PERMANENT CENTERS—THREE CENTERS IN A STRAIGHT LINE.

PART I.

IF WE watch a complicated machine in operation, we observe a seemingly great variety of motions. Some of the parts are rotating on axles or shafts; others are sliding in guides; certain connecting links have a curious complicated movement, which appears to be partly a sliding and partly a rotating, or turning; still other links have, perhaps, a screw-like motion. These motions of machine parts, and of bodies in general, furnish an interesting and useful subject for analysis and study.

All motions of rigid bodies may be primarily divided into two classes: *plane* motion and *non-plane* motion. A body has plane motion when it moves in such a manner that each point remains always in one plane during the motion, the planes in which the different points of the body move being parallel. Take, for example, the flywheel or pulley; it is evident that any point of the wheel always remains in a plane which is perpendicular to the shaft, and that the planes of the different points are parallel. A body having non-plane motion moves in such a manner that the path of any point is a curve in space; that is, a curve which does not lie in a plane. A familiar example of non-plane motion is the motion of a nut on a bolt; as the nut advances, it turns on the screw so that every point of it is describing a helical path. The universal joint is another instance of non-plane motion. By far the greater part of the motions met with in practice are plane motions, and in this article we shall restrict our study to motions of that class; so that, whenever we speak of motion, or say a body moves, it will be understood that plane motion is meant.

Every point of a moving body describes a curve (or a straight line) in the plane of its motion; this curve we shall call the *point-path.* The direction of a point's motion at any instant is given by the tangent to the point-path. Thus, suppose the point a of the body A, Fig. 1, moves in the curved path $a\,a'$. When the point is at a, the line $a\,b$—tangent to the path at a—shows the direction in which it is moving just at that instant. When the point is at a_1, the tangent $a_1\,b_1$ shows its direction of motion; likewise, the tangent $a_2\,b_2$ shows the direction when the point is at a_2. It must be carefully noted that the tangent gives the direction of motion just at the particular instant that the point occupies the given position. If the point moves ever so little from its position at a, the tangent changes its direction.

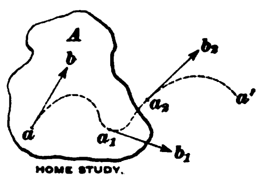


FIG. 1.

Since, in plane motion, all points are moving in parallel planes, the motion of the body, whatever its size or shape, will be determined by the motion of any thin slice parallel to the plane of motion. To illus-

trate this point, suppose we move a book in any manner upon the surface of a table; then the motion of the book as a whole will be represented perfectly by the motion of the thin cover next the table. This method of representing a solid object by a thin section is of great service, for we may consider the rotation of the body about an axis replaced by the rotation of the plane section about the point where the axis pierces it.

In order to obtain a knowledge of the motion of a body, we need to know all about the motions of *two* of its points. In Fig. 2, A represents a thin slice of a body. Suppose we stick an axis or pin p through the body, piercing the slice at o; the only motion the body can have is a rotation about the pin as a center, and therefore any point of the slice, as a, must describe a circular arc about o as a center. The direction of the motion of the point a, when it is in the position shown, is along $a\,b$, the tangent to the arc, and the direction of motion of any other point m is along the tangent $m\,n$ to its circular path. It is a geometric property of the circle that the radius $o\,a$ which joins the center o to the point a is perpendicular to the tangent $a\,b$; likewise, $o\,m$ is perpendicular to the tangent $m\,n$. These considerations lead to the following important principle: *The line joining the center of rotation to a given point is perpendicular to the direction of the point's motion; conversely, the center of rotation lies in a line drawn through the moving point perpendicular to the direction of the point's motion; that is, perpendicular to the point's path.*

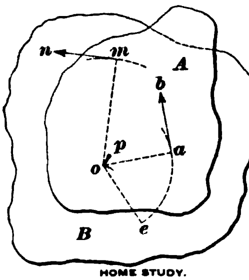


FIG. 2.

This principle enables us to determine the motion of any rigid body, provided we know the motions of two of its points. Suppose B, Fig. 3, to be a moving body, and that we know that the two points a and m are moving in the directions shown by the lines $a\,b$ and $m\,n$, which are, respectively, the tangents to the paths of a and m. If, now, we draw through a the line $a\,c$ perpendicular to $a\,b$, this line must pass through the center about which the body is rotating. Likewise, the line $m\,p$ perpendicular to $m\,n$ must also pass through the center, which must, therefore, lie at the intersection o of the two lines. It must not be supposed that the body continues to rotate about the center o for any length of time; this can only happen when the points a and m move in circles with o as a center, which is not necessarily the case. In the most general case, the points a and m may move in any curves whatever. Let us assume in the present instance that a is moving in the path $e\,f$ and that m is moving in the path $g\,h$. When a arrives at a_1 it is moving in the direction $a_1\,b_1$; at the same instant the point m is at m_1 and is moving in the direction $m_1\,n_1$. Drawing perpendiculars to $a_1\,b_1$ and $m_1\,n_1$, through a_1 and m_1, respectively, we find the center of rotation, at this particular instant, to be at o_1.

A special case of frequent occurrence is that in which the paths of the two given points a and m are parallel straight lines, as shown in Fig. 4. The perpendiculars $a\,c$ and $m\,p$ are also parallel; that is, their intersection lies at an infinite distance from the body. A motion of this character is called a *translation.*

We see that there are three (and only three) kinds of plane motion. They are: (1) Rotation about a fixed or permanent axis, or center, as shown in Fig. 2. (2) Rotation about a center, or axis, which is constantly changing its position, Fig. 3. (3) Translation, or rotation, about a center at an infinite distance, Fig. 4. An example of each of these motions is exhibited in the familiar mechanism of the steam-engine. The crank and fly-wheel rotate about a fixed axis, the center line of the shaft. The connecting rod rotates about a center which is itself moving, and the cross-head has a motion of translation.

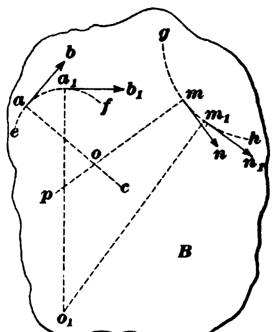


FIG. 3.

Every plane motion is a rotation about an axis, or center, which lies either at a finite or infinite distance from the moving body. If the center of rotation is one about which the body rotates for an instant only, as o, Fig. 3, it is called an *instantaneous center.* A center about which a body rotates permanently is called a *fixed*, or *permanent*, center.

So far we have considered such points as o, Fig. 2, and o, Fig. 3, merely as centers about which their respective bodies are rotating; there is, however, another conception of these points which is important. In Fig. 2 we have assumed that the body A is moving and that the body B is at rest. Now, motion is only *relative*, and, so far as these two bodies are concerned, it makes no difference in their relative motion which of the two is moving and which is at rest. For example, we can make point a of A coincide with point e of B, either by rotating A in the direction of the hands of a watch through the angle $a\,o\,e$, or by rotating B through the same angle in the opposite direction, in the meantime keeping A stationary. Similarly, in Fig. 3, the body B is moving relatively to some other body, which is assumed to be stationary, and the instantaneous rotation of B about the center o may be replaced by an equal rotation of the second body about o, in the opposite direction. In both cases the point o is the center of rotation, whichever of the bodies is considered as moving; that is, the center o belongs to *both* of the bodies. Suppose that the bodies A and B, Fig. 2, are moving relatively to each other, and that both are moving relatively to a third body, i. e., on the surface of a table or on a floor. The point o is common to A and B, and has the same motion whether we consider it as belonging to A or to B. The same is true if o is an instantaneous center; for the instant under consideration, it is the point (and the only point) which is common to A and B, and which has the same motion whether considered as a point of A or a point of B.

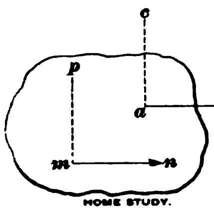


FIG. 4.

Let us now apply the principles so far developed to a concrete mechanism. In Fig. 5 is shown a combination of four bodies, a, b, c, and d; modifications of this mechanism are frequently used in machinery. We will consider the link d as stationary, and study the motions of the other three links relative to it. Links a and c being joined directly to d, must rotate about the joints $(a\,d)$ and $(c\,d)$, respectively, which are therefore permanent centers. Considering links a and b, if one moves relatively to the other, it must be about the joint $(a\,b)$; for a like reason, any motion of b relative to c, must be a rotation about $(b\,c)$. Thus, the four centers of the adjacent links are the four joints, and are permanent centers. To find the center of the motion of b relative to d, we observe that there are two points of b, viz., $(a\,b)$ and $(b\,c)$, which we know are moving at right angles to the links a and c, respectively. The point $(a\,b)$ belongs both to link a and to link b. Considered as a point of a, its path must be a circle with $(a\,d)$ as a center, and its direction of motion must be perpendicular to a. Considering $(a\,b)$ now as a point of b, the center of rotation of b must lie in a line perpendicular to the direction of motion of $a\,b$, which line must be a continuation of the link a. Likewise, the center must lie in a line perpendicular to the direction of motion of $(b\,c)$, which is a continuation of link c. Hence, the center $(b\,d)$ of the motion of b, relative to d, lies at the intersection of the continuations of links a and c. This center $(b\,d)$ may be looked at from two points of view. If we suppose the links b and d enlarged so as to include $(b\,d)$—for this purpose we may imagine two sheets of paper, one pasted on b and the other on d—the point $(b\,d)$ is the center about which b is rotating, considering d stationary; conversely, it is the center about which d is for the instant rotating, considering b stationary. If, however, both b and d are moving, the link a, for example, being stationary,

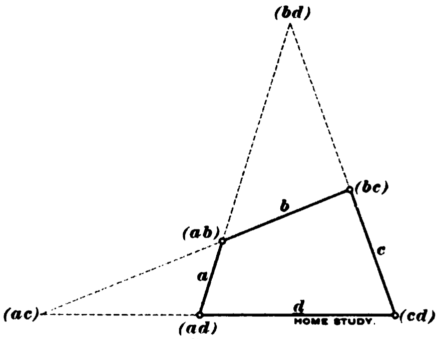


FIG. 5.

then the point $(b\,d)$ is the point common to links b and d, which has the same motion whether considered as a point of b or as a point of d. The instantaneous center $(a\,c)$ of the motion of a, relative to c, is found at the intersection of the continuations of links b and d; it is the point common to the links a and c.

An inspection of Fig. 5 shows that the three centers belonging to any three links lie in a straight line; thus the centers $(a\,c)$, $(a\,d)$, and $(c\,d)$ of the links a, c, and d, lie

in the line $(a\ c)$—$(c\ d)$. It can easily be proved that this must be true of any three bodies having relative motion. Thus, in Fig 5, if d is considered as stationary, every point of a must rotate about $(a\ d)$ as a center, and every point of c must rotate about $(c\ d)$ as a center. Now $(a\ c)$, as we have seen, is a point common to a and c. Considered as a point of a, it is rotating about $a\ d$, and, therefore, the perpendicular to its direction of motion must pass through $(a\ d)$; considered as a point of (c), $(a\ c)$ is rotating about $(c\ d)$ as a center, and the perpendicular to the direction of its motion must pass through $(c\ d)$. Since there can be but one perpendicular to a line at a given point, and since this perpendicular passes through both $(a\ d)$ and $(c\ d)$, it must be the line joining them. Therefore, $(a\ c)$ lies on the line adjoining $(a\ d)$ and $(c\ d)$.

The use of the instantaneous center in determining the velocities of the moving links of a mechanism will be considered in a future article.

HIGH RAILROAD SPEEDS.

H. Rolfe.

SPEEDS NOW AND IN THE PAST—CAUSES AFFECTING THE QUESTION—THE ENGINEER OF WAYS SHARE IN THE MATTER—RAIL-JOINTS.

THE demand nowadays is for increased speed in all modes of transit. The telegraph and the telephone have within the last few years brought the various cities and towns nearer and nearer together, as regards *communication*. This has satisfied business men to a great extent, facilitating immensely, as it has done, the transaction of business. A prospective buyer doesn't have to wait for an agent or drummer to come along; he can talk directly with the firm itself in a more desirable and expeditious manner than by letter, the expense of such a proceeding being curtailed in many cases by the use of special telegraph codes.

But the business man is not content with even this. He wants to be able to go rapidly from place to place in person, and this desire is shared by most other people. Very few persons take a railroad journey for pleasure, but simply because they want to get to some other place. In case this may be regarded as a truism, we would instance a converse case—sea-travel, which many indulge in for the sake of the journey itself.

Railroad speeds have, on some roads, increased greatly of late years, but not so much as many people might imagine. Heavier trains are hauled nowadays, but the speeds have not shown a very marked increase, especially in the matter of schedule time. This is, on second thought, not a matter for surprise. First, because the railroads are more crowded, especially in Europe, and secondly, because the engine of to-day is very similar to what it was 30 years ago. It has been enlarged all around, 'tis true; larger cylinders are being used, larger boilers, higher steam pressures, and all parts are made stronger and heavier, but in general design it remains very much the same. The engines of to-day of course take heavier loads, and work with greater economy; the average speeds, too, are perhaps somewhat higher in the majority of cases, although this is greatly due to better signalling—the adoption of the block system and the interlocking apparatus; the use of automatic continuous brakes, too, permit of these higher speeds being employed. But the maximum speeds of the engines themselves 25 years ago, compare very favorably with those of to-day, except in one or two exceptional cases.

In hinting at retrogression, the writer has in mind a certain English road whose mainstay is its passenger traffic. This road now runs the majority of its through expresses from London to a certain town in 70 minutes—one a day, each way, however, being *timed* to do it in 65 minutes (we italicize the "timed" advisedly). Now, 30 years ago the schedule time was 60 minutes, and they made it, too. The traffic was less crowded, of course, and the cars were smaller, but the loads were proportional to the power and weight of the engines. Again, during the "race to the North" that

has been indulged in during the last few summers in Great Britain, the majority of engines employed have been old types. Some noteworthy running on the L. N. W. was done by Webbs' 4-coupled *Precedent* class with 78-inch drivers. These engines, however, are practically the same as they were 20 years ago. As time progressed, and the rival concern began to make the pace hot, the above company trotted out the old *Lady of the Lake* class, first built by Ramsbottom as much as 35 years ago. They had a single pair of drivers, 91½ inches diameter, 16- by 24-inch cylinders, 1,100 square feet of heating surface, and only weighed 60,500 pounds, 25,750 of which was on the drivers. The boiler was 48 inches, outside diameter, and its center was but 6 feet 6½ inches above rail-level. With a load of not more than about 6 of their 6-wheeled coaches, these engines can hold their own to this day. The East Coast route relied chiefly on a type of engine first built nearly 30 years ago, and practically the same at the time we are speaking of. These also had single drivers, 97 inches diameter, however, in this case.

It is often stated in print that the G. W. R. (England) in 1840 ran trains at 50 miles an hour, and had engines that made 80 miles per hour without a train. The former statement is true enough, but the latter must not be taken too literally. Few men would like to run a "light" engine (that is, one without a train) at top speed. It is necessary to have a car or two behind to steady her. Doubtless the speed mentioned was attained with a very light load on a down grade.

There are not many regular trains running nowadays at a schedule speed of more than 53 miles per hour. Why shouldn't they be timed at 60? By far the fastest train in the world is the one that runs from Camden to Atlantic City in the summer months. This makes the 55½ miles, start to stop, in from 47 to 50 minutes, regularly. Still, the *maximum* speeds are not always attained by expresses. Often the fastest running is done by the stopping trains. The highest degree of skill and judgment is by no means called forth solely on the fastest and most important trains, where there is a through run, a clear road, and not much likelihood of overloading. Everything is done, in fact, to ensure their getting through "on time." But with a stopping train much time is often lost at stations by tardy baggagemen, or through late connections, or in waiting for the mails. If, under these circumstances, the engineman doesn't put his best leg foremost and make up a lot of the lost time, he doesn't advance in the good graces of his superior officers. On such trains one is likely to experience much faster bursts of speed than on the more prominent and popularly-known expresses; in fact, on the stopping trains the running often becomes right-down reckless.

As regards the accelerating of the journey as a whole, there are many points to be considered, militating for or against it, which we propose to consider briefly and in a general way, classifying them as follows:

1. The nature of the road; its freedom from curves and grades.
2. The quality of the track itself.
3. The condition of the rolling stock.
4. The operation and management of the traffic department.
5. The wind and weather.
6. Safety appliances. (The block system of signaling. Interlocking apparatus. Continuous brakes. Double tracks.)
7. The capacity of the engine itself.

1. *The nature of the work:* Great skill is now evinced in railroad location, avoiding sharp curves and grades as far as possible. They couldn't be expected to know it all in those early days; we've all had to learn, and we have also profited by other people's mistakes. There is little doubt that most of the earlier lines, if laid out afresh, would be easier and shorter, a freer use being made of cuts, tunnels, and embankments.

A great deal depends upon the nature of the country passed through, and also on the financial standing of the company. Sometimes the choice lies between sharp curves and grades on the one hand, and cuts, tunnels, and embankments on the other. If, however, the traffic is to be predominatingly passenger, and money is plentiful, we may assume that the road will be pretty easy—that is, comparatively free from curves and grades—and then a certain acceleration of schedule time may be counted upon.

2. *The quality of the track itself* will prove an important feature in the raising of train speeds. We want the engine and cars to move *forward* all the time; all motion in any other direction is wasted. It seems obvious that all lateral swaying, vertical pitching, etc. will detract to some extent from the speed.

A great deal of unsteady running is due to the track itself. It may be ballasted badly, either an unsuitable material being used or

the work being carelessly done. Large hand-packed stones or a good furnace slag, for bottom ballast, and broken stone on clean shingle for top ballast, make a good track. Whatever the material used, however, it should be accompanied by good drainage. If water accumulates in the ballast, evil results will ensue ; the ties will remain wet and therefore decay the sooner. If in addition to being badly drained, the ballast is also dirty, the up-and-down working of the ties due to the constant passing of trains, will churn the road-bed into mud, and so cause the ties to sink more and more under passing loads. These depressions in the track will have a retarding effect on the speed. It is also important to have a rail with plenty of strength, so as to prevent undue deflection. Peter Barlow, an engineer, some years ago investigated the matter of increased tractive force required, due to this deflection. Fig. 1 represents the part of the rail between two ties. The wheel, after passing over a, deflects the rail and therefore rolls down an inclined plane ; from b it has to ascend another similar plane. Barlow showed that the momentum acquired in falling down the first half of the span did not compensate for the work done in getting up the second half, and that the result was equivalent to a continuous additional slope, necessitating an increase of tractive force that becomes of material importance in the long run.

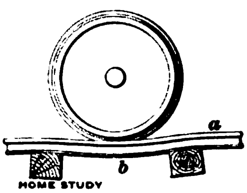


FIG. 1.

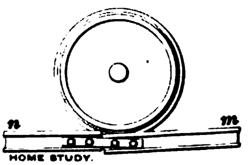


FIG. 2.

This was proved both in actual experiment, as above, and also mathematically by Sir G. G. Stokes. Whether it "cuts much ice" or not, it at least points out to us what to look after. In any future material increase in speeds the track will play an important part. Engineers are even now continually laying down stronger rails, both on account of heavier stock and higher speeds. 100-pound rails are in use both in this country and in England. We have seen, then, the importance of a good solid track, well laid and drained ; the gauge to be carefully attended to and varied to suit each curve. Although a *solid* bed is a desideratum, still it must not be rigid or inelastic. The evil of this was shown in early railroading days. A road was laid on solid blocks of stone, nothing interposing between the latter and the rails, and the stone bed being continuous. The result was that the rolling stock was shaken to pieces; the track was too hard and unyielding.

However good the track may be and however strong the rails, we are still confronted with the rail-joints as the weak spot. Considerable ingenuity has been spent in this connection, much of which might profitably have been bestowed in other ways. It's no use having all but one of the links of a chain sound; they must *all* be right. Good rail-joints are wasted on a badly packed or drained road-bed, or on ties that are too soft or too widely spaced to secure the proper bearing-surface for the rail. We lay our ties nearer together than they do in England, both because timber is cheaper here and also because our flanged rail does not present the same amount of bearing surface that their chair does. On account of the wider spacing of the ties it would seem that their rails ought to be stronger than ours. True, our engines and cars are much heavier ; but there's not much difference in the wheel-loads.

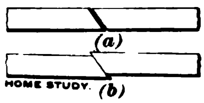


FIG. 3.

The rail deflection is still further increased when we come to a joint, for no joint ever devised (or likely to be) is as rigid as the solid rail. Also, when the wheel passes over a joint that is either inherently weak or has become loose—through the bolts slacking back or the holes having worn—the wheel (see Fig. 2) deflects the rail m and therefore strikes the rail n a violent blow.

Now, the repetition of this blow at every rail-joint, on each side of the track, and occurring to every wheel of each vehicle, undoubtedly detracts from the speed ; for we may regard the rail-end as striking the *wheels* and tending to drive them backwards.

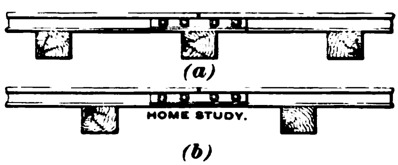


FIG. 4.

It certainly does not minister to the comfort of passengers, as any one who has traveled in Europe can testify ; this bumping is much more in evidence there than here. The easiest road in England is the G. W. R. ; this runs on longitudinal continuous ties. It is difficult to drain such a track, however. The bumping-joint alluded to can be minimized by putting in 60-foot rails instead of 30-foot. This is done on some roads. Also, the ends of the rails can be cut at an angle, as at (*a*), Fig. 3, instead of straight across. Rails thus cut can be supplied at about the same cost as ordinary ones ; it is strange, therefore, that they have not come into more general use. About the only objection raised against them is that if the ends should ever butt together (in very hot weather) the tendency is for them to be displaced sideways, as shown at (*b*), Fig. 3. With this kind of rail though, we can employ great lengths, as the necessary extra opening at the ends (required on account of the increased expansion) is less objectionable than when cut straight across. Although, as remarked, the value of a good joint is discounted by a bad track, still it behoves us to get as good a one as possible. At first sight one would be inclined to think that the joint shown in *a*, Fig. 4, was the best to use, as here the weak place (the space between rail-ends) is supported directly on the tie. But experience has universally demonstrated that the arrangement shown in *b* is the better one. This is called a suspended joint. The first one is a supported joint. In England the pitch of the ties varies from 24 inches at the rail-joint up to 36 inches at center of rail length, the pitch gradually increasing. In this country the pitch is uniform, about 18 inches. Ties should be well-seasoned before using. To preserve them from decay, ants, etc. they are treated chemically. either *creosoted* or *burnetized*. The latter process rusts the spikes away, however, while the former preserves them ; anything which tends to impair the tightness and compactness of the track should be avoided.

(To be Continued.)

HOT-WATER SUPPLY.

Thos. N. Thomson.

Circulation Between Ranges and Boilers — Location of Boiler — How to Connect Up a Boiler in Basement with Range on Floor Above.

A KITCHEN boiler is simply a reservoir or storage tank to receive hot water and retain it until it is drawn off at some of the faucets in the building. Its capacity should be such as to store a quantity of hot water sufficient for the demands of the occupants of the building, at all times. Although the most common practice in the United States is to place the boiler in a vertical position, and quite close to the kitchen stove or range, it does not follow that this is the only place for its location. Neither does it follow that this is the best place, under all circumstances. The advantages of this location for the hot water storage tank are so numerous that plumbers, without considering the matter, simply set the tank there because they know from past experience that good results will be obtained by placing the tank close to the range.

This practice seems to have given the name "kitchen boiler" to the hot water storage tank, because it appears that no matter where the boiler is to be set, or from what source the water in it will be heated, it will still be called a kitchen boiler.

Whether the name, kitchen boiler, is a misnomer or not, will, of course, depend upon the location of the boiler, or its duty. We will not consider this matter here, however, but rather proceed to study the different methods of fitting up boilers or storage tanks located at different points, and in order to do so in a clear manner we will first study the transmission of heat from the burning coals in the range to the water in the tank.

One of nature's clearly defined laws is that heat will always pass between bodies having unequal temperature ; it will always flow in the direction of the colder body and operate to raise its temperature until all the bodies have the same temperature. For example, place a piece of red hot iron in a vessel of water, heat will rapidly pass from the iron to the water and raise its tempera-

ture. It will continue to heat the water until the iron and the water are at the same temperature. Or, if we place a piece of what we call cold iron in a vessel of boiling water, the same thing will happen, i. e., heat will flow from the warmer to the colder body, in this case from the water to the iron, until both bodies finally reach the same temperature.

Since the ordinary coal fire has a higher temperature than the water-back and the water it contains, it follows that the water-back (which is usually a cast iron closed box having a partition cast inside), will receive heat from the fire. This will tend to raise the temperature of the water-back to a point near that of the fire, but, as the water-back rises in temperature, heat flows from this iron body to the water which it envelops. The particles of water in contact with the inner surface of the water-back, being thus heated and consequently expanded, or made less dense, are buoyed upward, so to speak, and rise in the pipe which connects the top of the water-back to the side of the boiler, colder water entering the bottom of the water-back by the pipe which joins it to the bottom of the boiler. This movement of the water between the water-back and the boiler is what is commonly called "range circulation," and the force of gravity is the power which moves the water.

In order to obtain a gravity circulation between a water-back and a boiler, or, indeed, between any other points, there must be a difference between the mean density of the water in either tube or chamber, which connects the two points. The tube which contains the least dense, or, in other words, the hottest, water is called the "flow pipe," and the other is called the "return pipe." The velocity of the circulating current will depend upon the difference between the mean density of the water in the flow pipe and that in the return pipe, or chamber; also, upon the vertical height of the circulating current above the water-back, and, it may be said, upon resistances to the current, due to friction, change in direction of the current, etc.

The student now understands the fundamental principles of circulation by the force of gravity, and he should be better enabled to reason out systems of circulation adapted to the varied conditions which exist in building construction.

In this article we will treat upon two extreme or unusual cases, one being that in which the hot water storage tank must be placed on the top floor of the building, and the other that in which the tank must be placed in the basement, and lower than the point at which the water will be heated.

Fig. 1 is an illustration of the former case. The storage tank *a* is located on the top floor, and lower than an ordinary house tank *b*, which we will suppose supplies water to the building. The cold water tank *b* joins *a* by a communication, or cold water feed-pipe *c*, and *a* joins the water-back in the kitchen range *d* by means of two pipes, *e* and *f*. This apparatus operates as

FIG. 1.

follows: Water in *b* flows by gravity through *c* into *a*, then down through the pipe *e* which joins the bottom of *a* to the bottom of the water-back. The water then passes through the water-back and rises in *f* until *a* is filled with water up to the level of the upper end of *f*, which stands about half way up inside *a*, or joins its sides at about the same level. The lower end of *f* joins the top of the water-back. The pipe *g* joins the top of *a*, which is closed water-tight and delivers openly over the top of *b*. The pipe *h* joins *a* near its top, or at least at a point below the level of

the bottom of the supply tank *b*. Branches are taken from this pipe to the several fixtures in the building. When the system is entirely filled with water, and before a fire is started in the range, the water throughout is, practically speaking, at rest, i. e., there is no perceptible motion to any part, and the density, or temperature, is equal throughout.

When a fire is started in the range *d*, water in the water-back will become heated and will rise in *f*, very slowly at first, increasing in velocity as the pipe *f* becomes heated. As the hot water flows from *d* through *f* and into *a*, an equal weight of cold water flows from *a* down through *e* and into *d* to replace it. This movement of the water we call circulation between the range and the storage tank, and it is in this way that heat is conveyed from the range to the water in the storage tank, the water itself being the conveyor of heat. The hottest water will always rise to the highest points, because it is less dense than colder water, consequently the hottest water in the apparatus shown will always rise, or tend to rise, to the top of the storage tank *a*, and because of this the distributing pipe *h* draws water from the top of *a*.

Circulation between *a* and *d* will continue so long as *f* is warmer than *e*, or *vice versa*. When these pipes reach the same temperature, the water they contain becomes equal in density, and circulation, consequently, will cease.

Fig. 2 shows the same building, containing the same fixtures, house tank and range, fitted up in a different manner. The object here is to have the hot water storage tank *a* located in the basement, as shown.

We know that if the boiler and the range are connected by two pipes dropping directly from the range to the boiler, circulation will not take place between these points, because the hot water, obedient to the law of gravitation, will remain in the water-back and the cold water in the boiler. There will be no force present which will raise the cold water to the water-back, and so displace the hot water and cause it to flow down to the boiler. The water would simply remain in the water-back until part of it was converted into steam, when, by the enormous expansion of the water so changed to the gaseous state, the greater part of the hot water would be forced down the pipes which connect the water-back to the boiler, and the water-back then being full of steam instead of water, would soon become overheated. Such a condition is usually made manifest by snapping or hammering and rumbling sounds.

In order to obtain a force or power sufficient to cause the hot water to descend to the boiler and thereby secure a circulation between the boiler and the range, the flow pipe *f* is extended vertically upward as far as the circumstances will allow, then returned and dropped downward to the boiler, as shown by *f* and *e* in Fig. 2.

When this system is full of water and before a fire is started in the range, the water will be at rest throughout the system,

Fig. 2.

as in the preceding case, because the temperature throughout is equal. But as soon as a fire is started in the range and the water-back becomes heated, the hot water will proceed to flow up *f*, and circulation will commence. As it rises in *f* the velocity of the circulation will increase until the hot water reaches the top of the loop formed by *e* and *f*, when it will have obtained its maximum velocity. The reader will observe that *e* is still filled with cold water, while *f* is now filled with water at a higher temperature, which we take the liberty to call hot. The density of the water in the columns

e and f being unequal, it follows that the hot water will flow down e and take the place of the cold water, which thus falls into the boiler. The velocity of the circulation will now, however, begin to decrease, because as the hot water descends in e the mean density of the water in this tube will approach that of the water in f. The tube e, however, cannot attain a temperature as high as f, because the hot water will have given off some of its heat to the atmosphere, etc., before it travels very far, and the lower the velocity of circulation the more heat will be given off by a certain weight of water in a given time, consequently the slower the circulation the greater will be the difference between the densities of the water in the tubes e and f. It will thus be observed that circulation must take place between the range and the boiler.

There is one feature in this arrangement, however, which we must not leave unconsidered, which is, that a certain drag is made upon the circulation by connecting the water-back feed pipe i to the bottom of the boiler, as shown. When the boiler is filled with hot water, the column of cold water in this pipe really forms a resistance which must be overcome by a difference in density between e and f. The effect of cold water in i and hot water in a is contrary to the effect of hot water in f and colder water in e.

Summing up, we may say that the actual effective force which operates to circulate the water in the direction shown by the arrows, is, the mean density of the water in f, plus the mean density of the water in i, minus the mean density of the water in e, plus the mean density of the water in the boiler.

When a system of piping similar to that shown in Fig. 2 is employed, particular care must be taken to arrange the work in such a manner that the water-back cannot be accidentally drained empty by shutting the water off and draining the branches for repairs. It should be so arranged that the hot water may be shut off from the fixtures without interfering with the range circulation. This can be easily accomplished by placing stop cocks where shown in the figure.

The reader must understand that although we illustrate and describe a method of connecting up a boiler in the basement to a range above it, we do not recommend its use, when it is possible to locate the boiler higher than the range.

SEWAGE DISPOSAL.

Benj. F. La Rue.

THE POLLUTION OF STREAMS AND MENACE TO THE WATER-SUPPLY—SANITARY CONDITIONS INVOLVED—VARIOUS METHODS OF PURIFICATION EMPLOYED.

THE growth of urban population has been very rapid during recent years, showing a remarkable increase in the population of nearly all cities and towns, but more especially of the large cities. This condition has rendered more complex the problems confronting the civil engineer working along the lines of water-supply and sewerage. The rapid increase of population greatly augments the flood of sewage poured into the streams, polluting the natural sources of water-supply, and also intensifies to a corresponding extent, the demand for pure water.

Sewage is the term applied to the solid and liquid wastes of the human economy, as well as to street washings and factory wastes, and also to the water combined with them for the purpose of removal. The popular idea regarding sewage is simply that it is something so essentially repulsive that it must be kept entirely out of sight; and the old principle of *out of sight out of mind* applies. So long as the sewage does not offend the popular senses, it receives little popular attention.

This attitude of the popular mind in regard to sewage is radically wrong, and has much retarded the development of sewerage as a science. The waste of the human system is as certainly a vital and unavoidable fact of existence as is the food on which it subsists; and the important problem of disposing of the waste under sanitary conditions should neither be evaded nor ignored, but should be met fairly, and dealt with upon its merits.

In most country districts and small

villages, and in many outlying suburbs, the sewage is discharged into vaults and cesspools, where it remains to putrefy, contaminating the surrounding earth and atmosphere. Though producing the most unsanitary conditions, it is hidden from view, and, consequently, receives no further attention. In cities, the sewage is removed promptly by the sewers, before offensive conditions can arise. So far as the popular mind is concerned, it has disappeared; what more can be desired? That the sewers are merely conduits for removing the sewage to other localities, and that the sewage thus removed may produce offensive, unsanitary, and even dangerous conditions in the localities where discharged, are features of the matter having little popular interest.

The most common method of disposing of sewage is to discharge it into the nearest stream or other body of water. This method of disposal is convenient and cheap, and, under proper conditions, is permissible. If, however, where this method of disposal is employed, the discharged sewage forms more than a very small fraction of the total volume, the water may become so polluted as to be not only wholly unfit for any domestic use, but also a dangerous menace to towns whose water-supplies are derived from the same streams lower down. The objections of such towns to the pollution of their water-supply, and the legal proceedings that have in some cases been instituted to prevent it, have done much toward directing attention to other forms of sewage disposal.

That every riparian proprietor is entitled to have the stream on which his realty is situated flow past his domain in its natural course and condition, is an old and well-established principle of law; and from this principle is derived directly the almost equally well-established doctrine that to pollute a public stream is to maintain a common nuisance. Although the necessities and conditions of modern society require some deviation from the strict letter of this broad principle, it is accepted as being, on the whole, sound legal doctrine. The Royal Sanitary Commission of Great Britain, created in 1869, recommended that any stream from which drinking-water is taken should be effectually protected from sewage pollution. The spirit of this recommendation is in harmony with the attitude of the law, and is quite generally considered as one of the fundamental principles of sanitary engineering. It has been gradually extended to include all streams that are likely to become sources of water-supply, by at least the provision that, if sewage be discharged into such streams, it shall be under such conditions that the pollution can be terminated whenever the water is required for domestic purposes. There is a growing sentiment in favor of protecting the streams and small inland lakes from pollution by town

View of a Corn-field Illustrating Irrigation by Sewage.

sewage. For it is realized that this is necessary if, as the density of population increases, we are to continue to have a supply of pure drinking-water.

The more dense the population becomes, the greater will be the supply of water required, and, at the same time, the greater will be the discharge of sewage and consequent pollution of streams. The harmonizing of these two opposing influences presents a problem that is by no means insignificant at the present time, and in the future is likely to assume such proportions as to considerably modify social conditions. In the arid and semi-arid regions of the West, the supply of water must, even under present conditions, be carefully husbanded; and if, in those regions, the population ever becomes exceedingly dense, it will be necessary to utilize every drop of the available supply—a condition that will render the proper and sanitary sewerage of the region extremely difficult. In some parts of the East the population has already become so dense, and the water supply so affected by sewage pollution, as to give the matter a serious aspect, and make remedial measures necessary.

The remedy employed for the amelioration of this condition is sewage-purification. The sewage effluents are purified and rendered as nearly innocuous as possible before being discharged into the streams. A number of sewage-purification plants have been established in various parts of the country, and the results obtained have been, in most cases, highly satisfactory. Indeed, so high a degree of purification has been reached in some cases as to render the purified sewage effluent chemically purer than the average supply of drinking-water, and there appears to be no reason, other than popular sentiment, why such a purified effluent may not, with perfect safety, pass into a stream from which a public water-supply is obtained. The very valuable experiments of the Massachusetts State Board of Health has shown that there is no difficulty in removing from 95 to 99½ per cent. of the organic impurity. In view of the great importance of the subject, it will be of interest to notice briefly the most common methods of sewage disposal and some of the means employed for purification.

Those methods of disposal that have been tested on any considerable scale, and have proved to a reasonable degree successful, may be classified as natural disposal, clarification, and application to the soil. Space permits here only a brief notice of these different methods of disposal.

Natural disposal and *dilution* are terms sometimes used to designate the practice of discharging sewage directly into a stream or other body of water without previous treatment. This method of disposal, being both cheap and convenient, has been extensively employed, and, under proper conditions, its results may be neither offensive nor unsanitary. When untreated sewage is discharged into a stream of water, the water immediately below the sewer outlet will be rendered extremely impure. But if the water is of sufficient volume in comparison with the volume of sewage discharged into it, and is sufficiently in motion, exposing it to the action of the atmosphere, a change will take place and the water will gradually become purified, so that, at a distance of a few miles below the sewer outlet, all traces of the sewage will have disappeared. Not only will the sewage become very highly diluted by the comparatively great amount of water, but a certain degree of actual change, or purification, will also take place.

This change, which is sometimes called *self-purification*, is due to several causes. Some of the organic matter becomes food for aquatic vegetation and animal life; some combines chemically with the oxygen of the air and water, forming inorganic compounds; more or less chemical change is due to the presence of micro-organisms; while much of the solid matter is separated and deposited in particles along the bed and banks of the stream. The greater the comparative volume of the water, and the swifter its current—giving greater exposure to the atmosphere—the more rapid and effectual will be the purification. The degree of purification that can be obtained by this method of disposal is quite uncertain, however, and it would be extremely hazardous to discharge untreated sewage into a stream used as a source of public water-supply. It is safe to state that this method of disposal is employed in very many cases where it ought not to be.

Clarification consists in removing the greater portion of the solid matter and, by some processes, a portion of the dissolved matter from the liquid sewage before discharging it into a stream or other body of water. The effluent, though by no means approximating pure water, is much less objectionable than the original sewage. The degree of clarification obtained will

depend upon the process employed and the thoroughness of its application. Three general processes of clarification are employed, namely, sedimentation, mechanical filtration, and chemical precipitation.

By the process of *sedimentation*, called also *subsidence*, the sewage is collected in tanks or reservoirs and allowed to stand until the solids have settled to the bottom, after which the water is drawn off slowly, discharging into a stream or body of water. The effluent, though somewhat clarified, still remains highly charged with impurities.

By the ordinary processes of *mechanical filtration*, the sewage is simply passed through filters or screens of various kinds. Such processes remove a larger proportion of the solid matter than can be removed by subsidence, but leave the effluent still very impure.

Chemical precipitation is the direct outgrowth of unsatisfactory sedimentation. The sewage is collected in tanks or reservoirs, and with it are mixed certain chemical solutions which precipitate not only the solid matter but also a portion of the matter held in solution. Various chemical processes are employed, a large number of which have been patented. The effluent from sewage clarified by any process of chemical precipitation is, however, far from being pure water, and is liable to decompose after being discharged into a stream. Moreover, the addition of the chemicals used is more or less deleterious to the water. This method of purification is not of itself sufficient where the effluent is to be discharged into a stream from which a public water-supply is obtained.

Application to the soil is, beyond question, the most satisfactory and effectual means of purifying sewage. Those natural waters that have undergone prolonged filtration through the soil are the most free from organic matter. As the water passes through the soil, the organic matter is obstructed and retained, or taken up by vegetable growth. Under favorable conditions, water may become highly purified by this means, though it is still uncertain whether water that has been contaminated by sewage can be rendered so pure as to be safe for domestic use. It may be of interest, however, to notice that the managers of the Berlin sewage farms are said to have stated that, although the workmen are strictly forbidden to drink the water from the sewage-effluent, it is impossible to prevent them from doing so.

In applying sewage to the soil for the purpose of purification, two general processes are employed, namely, broad irrigation and intermittent filtration.

Broad irrigation is the most satisfactory and effectual means of sewage purification yet tried, where sufficient suitable land can be procured. It includes quite a variety of methods, differing more or less in detail, all of which consist, essentially, in applying the sewage in such manner and quantity as to irrigate and fertilize the soil for the growth of vegetation. This appears to be the most natural and economic method of sewage purification, involving the familiar processes of decomposition and growth under natural conditions, and utilizes by irrigation and fertilization the full economic value of the sewage. As the amount of sewage that can be applied to a given area, however, without being detrimental to the growing crops, is limited, this method requires extensive areas; hence the name *broad* irrigation. In the vicinity of large cities land is very valuable, and in order to require less areas, a modification of this method is employed. It should be stated, however, that it may be seriously questioned whether greater profits cannot be obtained from land utilized for irrigation than have yet been obtained in America, thus permitting the use of more valuable land for this purpose. In order that renewed supplies of oxygen may enter the soil to maintain the oxidizing processes, the application of sewage, commonly spoken of as the *dose*, must be intermittent. If, without regard to the requirements of vegetation, the amount and frequency of the dose is increased to nearly the full capacity of the soil, the irrigation will be converted into intermittent filtration.

Intermittent filtration may be considered as copious irrigation devoid of its utilitarian features. Both upward and downward filtration have been tried, the latter having given the more satisfactory results. The sewage is flooded upon ground that has been prepared for the purpose and thoroughly underdrained, and is filtered by passing downward through the soil to the drains. The filtration is not merely mechanical, however, but is largely a chemical process. While the soil, to some extent, acts as a mechanical filter in straining out portions of the solid matter, the purification is chiefly of the nature of chemical change, involving oxidation and nitrification, brought about largely through the agency of micro-

organisms called *bacteria*, contained in the sewage.

It is thus seen that the sewage contains within itself the means of its own purification, and, when the proper conditions are present, virtually becomes its own purifier. Under the favorable conditions afforded by intermittent filtration, purification is effected by the bacteria; and these minute organisms, having performed their important work, finally succumb to the action of oxygen and wholly disappear. If the filter-beds are properly prepared and the application of sewage properly regulated, the beds will not become fouled and ineffective by use, but will, within limits, become more and more effectual.

These facts, though pertaining to an unattractive subject, relate to some of the most beautiful and interesting of nature's processes; they are worthy of more attention than they have received, and should be more fully investigated and more generally understood. They illustrate, too, the universal principle that in the workshop of nature there is no room for a sluggard. Every individual entity, however minute, has its work to perform, and, having completed that work, the inflexible laws of nature's economy require that it shall no longer exist in that particular form, but shall pass to another state of existence in which it may again be useful.

GAS-ENGINE GOVERNORS.

E. W. Roberts.

EARLY METHODS—MODERN GOVERNORS FOR ELECTRIC LIGHTING—COMPARISON OF THE VARIOUS METHODS—THE PENDULUM GOVERNOR.

THERE are very few motors, whether run by water, steam, electricity, or gas, which will not vary in speed under a change of load. The motor will slow down as the load increases, and vice versa, unless there is some device attached to it that will vary the power supplied to the motor according to the variation in the load. When an engine is to be used for driving machinery, a governor is an absolute necessity, and for the purpose of driving textile machinery, or electric-lighting dynamos, the governor must regulate the speed to within a very small per cent. of uniform.

In the early days of the gas-engine, the matter of close regulation of speed was not given a great deal of attention, but its gradual adoption as a motive-power in every branch of manufacture, has compelled the gas-engine builder to give more attention to this matter. The requirements for modern dynamo-driving are unusually severe. Not only must the engine make a certain number of revolutions per minute, but a motive-power is required in which the speed will be practically uniform throughout one revolution. This is necessary because a diminution of speed means a drop in the electrical pressure on the circuit, and this causes flickering lights.

The subject of gas-engine governors may be divided under two heads: first, the manner in which the govenror controls the speed of the engine; second, the mechanism of the governor itself. For the purpose of distinction, the first division will be called *methods* and the second *mechanisms*.

There are at least five distinct methods of governing in gas-engine practice:

I. Entire stoppage of the gas supply when the speed gets beyond the limit, the gas admission-valve remaining closed until the speed falls, the engine in the mean time compressing and expanding a charge of pure air.

II. Partial stoppage of the gas supply, the quantity of gas admitted being graded to suit the variation in the load and the explosive force of the mixture being weakened.

III. Partial stoppage of both gas and air, the *proportion* of each remaining the same.

IV. Holding the exhaust-valve either open or closed during one or more strokes of the piston. This is equivalent to stopping the gas supply as in Method I. Neither gas nor air is able to enter in the one case because the engine retains the products of combustion. In engines where the exhaust-valve is held open the gas admissicn-valve is opened automatically by the suction of the piston and when the exhaust-valve is

open there is not sufficient suction to permit the entrance of the gas.

V. Stopping the action of the igniter—used in electric ignition, the governor throwing a switch and stopping the flow of the current. The charge is then alternately compressed and expanded until the speed falls and the igniter comes into operation again.

Method I was well enough for ordinary purposes, but for that of producing a practically uniform speed with changing loads it is useless. This method of governing produces a series of spasmodic starts, like that given by a lazy horse when the driver applies the whip. The starts would be most frequent when the load was heaviest, so that a quite steady speed would be maintained if the engine were loaded to its full capacity.

Methods II and III are those most generally used by manufacturers for close regulation. Method II being, perhaps, the best for regulation within a limited range, when the load is practically constant and near the full capacity of the engine. At very light loads the gas must be cut off entirely, as in Method I. Within those limits where the gas supply is not entirely cut off, this method is quite satisfactory and has the advantage of being economical, since the compression pressure is always the same. For wide ranges of load, Method III will give the best results, for the explosive mixture is admitted in every cycle, and the engine does not miss an impulse. The result is very similar to that obtained by the modern high-speed engine with a slide-valve governor.

Methods IV and V are very little, if any, improvement on Method I. The interference with the exhaust or the ignition really produces the same effect, since the engine must miss an explosion. A possible advantage over Method I lies in the retention of a quantity of gas in the cylinder when the exhaust-valve is closed. The engine will then do useless work on the enclosed material, while the latter acts as a brake. Although the speed regulation is better, power is wasted, and the economy of the engine is lowered. Governors which hold the exhaust-valve open are not subject to this last objection, and since no compression takes place when an impulse is missed, as invariably happens under Method I, the consequent small waste of power is avoided.

Gas-engine governor mechanisms are nearly as numerous as gas-engine makers. Only a few of the typical ones can be treated here.

The first governor employed for gas-engines was naturally that suggested by the type used on the steam-engine and known as the conical pendulum ball-governor, a form of the centrifugal.

An illustration of this type of governor is given in Fig. 1. It is the latest type brought out by the makers of the Sintz engine. It controls the speed by a modification of Method III. The balls *b* are rotated by the bevel-gears *g* and belt *f* from a pulley on the crank-shaft of the engine. The balls *b* are attached by links to the

Fig. 1.

the collars *l* and *m*, *m* being stationary, while *l* is free to move in a vertical direction.

As the engine "speeds up," the balls are thrown outward by the centrifugal force, depressing the bar *l*. As the bar *l* moves downward, it carries the rod *a* with it, thus rotating the bell-crank *c*. The stem of the mixing-valve projects at *u* and when not checked by the action of the governor it rises at each up-stroke of the piston to admit a fresh charge to the crank-chamber. Should the speed of the engine get too high, the rod *a* is depressed, rotating *c* until the beveled end *t* slides in front of *u* and prevents the valve from opening. No fresh mixture can enter the crank-chamber until the speed of the engine falls and *t* returns to the position shown in the figure, allowing *u* to rise. Although this method cuts off the supply of gas and air from the crank-chamber, sufficient fresh mixture remains to supply a small quantity to the working end

and give a weaker impulse to the piston on the next revolution. The speed of the engine can be changed while it is running by means of the nuts *n* and *o*. For example, if it is desired to increase the

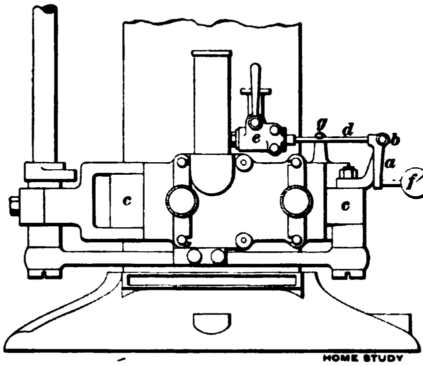


FIG. 2.

speed of the engine, the nuts are screwed down; this raises rod *a*, and the collar *l* has to move farther down before *t* will stop the motion of the valve.

Fig. 2 is a form of governor used on the smaller sizes of the Otto slide-valve engines. It is, perhaps, as simple a mechanism as has ever been devised for the purpose. It regulates the speed by Method I. The governor proper has but two essential parts, the bell-crank *a*, and the adjustable weight *f*. The crank is pivoted at *b* on a bracket projecting from the end of the slide *c c*. So long as the speed of the engine does not exceed the required limit, the gas-valve *e* is opened at every other stroke of the slide by the tongue *d*, attached to *a*. Should the speed exceed the limit, the ball *f* lags behind and swings in the direction of the arrow. This brings the tongue *d* below the stem of the gas-valve, and the valve is not opened again until the speed drops below the speed limit. The stop *g* keeps the tongue from rising above the stem of the valve while the engine is being started and until it gets up to speed.

This mechanism is known as the pendulum-governor. Its action depends upon the fact that a pendulum of a certain length will always make the same number of oscillations per minute. If the number of strokes of the slide is the same as the number of oscillations of the pendulum, they will move together. If the rate of the slide's motion exceeds the rate of the pendulum, the ball will lag behind. The longer a pendulum, the slower will be its rate of swing, so that, moving the ball to the right, causes the engine to run more slowly, and vice versa. There are many modifications of this mechanism, all of them based on practically the same principles.

Fig. 3 is a device employed by the makers of the Otto engine for governing by Method II. It is known as the Otto electric-light governor. A similar governor, regulating by Method I, was used on the first engine built. It consists of a ball-governor *G*, rotated by a pair of bevel-gears *g* from the valve-shaft. As the balls spread with the increase in speed, the lower arm of the bell-crank *e* falls, moving the collar *a* to the right, bringing one or the other of the steps of the cam *c* in contact with the roller *b*, and opening the gas-valve *d*, or, if the speed rises rapidly, moving the cam entirely out of the way of the roller, as it appears in the figure. The step of the cam at the right-hand end of the collar holds the valve open the longest, while in the position shown in the figure the valve does not open at all. Thus, the amount of gas admitted to the engine is varied through a limited range, and finally the gas is cut off altogether.

The devices just described can readily be

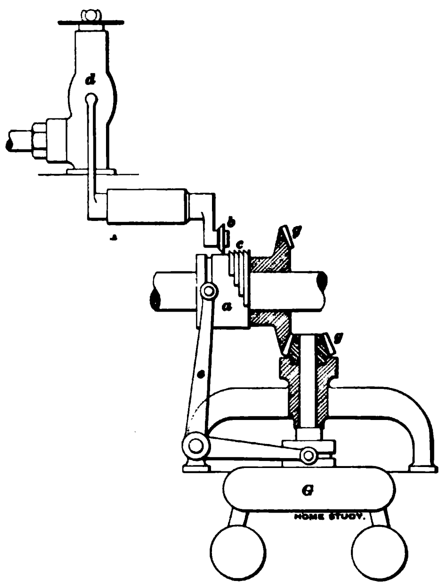


FIG. 3.

applied to Method IV. Any mechanism which will at the proper moment open a switch and thus break the circuit can be applied to Method V. The method is, however, but seldom used.

REQUIREMENTS FOR A GOOD LEVELING.

Benj. F. La Rue.

INSTRUMENTS—SOME ARE BETTER ADAPTED TO RAPID AND ACCURATE WORK THAN OTHERS. THE CHIEF REQUISITES: STABILITY, A GOOD TELESCOPE, AN ACCURATE SPIRIT-LEVEL.

THE difference between the elevations of points on the earth's surface may be determined, with a very high degree of accuracy, by means of the engineer's leveling instrument, if the work is done with care and the instrument used is an accurate one. If the instrument is not only accurate in its construction and adjustments, but also well adapted in other respects to the work, a line of levels may be run with a very considerable degree of precision and, at the same time, very rapidly.

Although it is quite possible to do reasonably accurate work with a poor instrument, it cannot be done with much facility, and will involve much greater liability to error than when the instrument used is accurately made and well adapted to its work. Especial stress is laid upon the latter property. It is fully as important that a leveling instrument should be in every way well adapted to its work as that it should be exceedingly exact. For, although some degree of accuracy is always required in running levels, the degree will vary considerably with the nature of the work in hand, and extreme accuracy will seldom be required. Moreover, instrumental errors can very often be largely, if not wholly, eliminated from a line of levels, without material loss of time, by the exercise of care and judgment in the prosecution of the work. But, if the leveling instrument used is unsteady in a light wind, is constantly getting out of adjustment, or has such a poorly defining telescope as to render the sighting difficult and uncertain, much time will be unavoidably lost. Any such loss of time, however, is wholly unnecessary, as there are quite a large number of engineers' leveling instruments made in this country that are thoroughly adapted to their work in every way. Of these instruments, all of which, probably, have merit, some possess to a greater degree than others the qualities that commend them to the civil engineer. It may here be well to add that engineers are by no means all of the same opinion in regard to what is the best make of leveling instrument, each engineer usually having his own particular favorite, which is generally the instrument that he has found to be best adapted to his own line of work. All field-engineers, however, are agreed in regard to certain qualities being essential to a satisfactory leveling instrument. These qualities will now be noticed, wholly without regard to any particular make of instrument.

The things most essential to a satisfactory leveling instrument are stability, a clear and sufficiently powerful telescope, an accurate and sensitive level and, of course, good material in the construction of all its parts, together with the best of workmanship.

Stability is a very essential property. When an instrument trembles in every slight gust of wind, it is not only very annoying, but also causes the loss of much valuable time. The most stable instrument will be affected by the wind when it blows with sufficient severity. Every field-engineer knows what it is to wait until his rodman and the entire field of view has stopped dancing a jig, or, in other words, until the trembling or other movement of his telescope, caused by the wind, has ceased. While all instruments are affected by the wind, some are influenced to a much greater extent than are others, depending upon their weight and construction. The stability of a leveling instrument is affected principally by three conditions, namely, its weight, the stiffness of the tripod-legs, and the distance of the telescope above the tripod-head.

A heavy instrument is less affected by the wind than a light one. This is because the inertia of the heavy instrument is greater than that of the light one, requiring that a greater amount of work be done by the force of the wind in order to produce movement. So far as stability is concerned. weight is a desirable feature and, on this account, some engineers prefer rather heavy instruments. As, however, leveling instru-

ments have generally to be carried several miles during each day's work, most engineers prefer to have them as light as is consistent with stability. In other respects, they are generally constructed with a view to having as great stability as possible, the desired end being attained more fully in some than in others of the same weight.

Stiff, substantial tripod-legs are absolutely essential to stability in a leveling instrument. Probably no other single condition so greatly affects their stability as the stiffness

FIG. 1.

of the legs, although many engineers often overlook the fact. The writer had always attributed the slight rotating movement of his telescope in a vertical plane to the springing of the metallic parts of the instrument, that is, to the springing of the center and of the horizontal bar carrying the telescope, until convinced by observation that it was caused by the wind-pressure against the tripod-legs. He had noticed that, when sighting in the direction that the wind was blowing, that is, with the object-end of the telescope to the leeward, the rotative movement of the object-end of the telescope was always *upward*, or in the opposite direction to what it would move if the springing were entirely or principally in the metallic parts. In seeking an explanation, he was forced to the conclusion that the springing occurred principally in the tripod-legs and was caused by the wind-pressure.

The character of the movement is shown in Fig. 1, in which, for the sake of clearness, the distortion of the instrument is greatly exaggerated. This conclusion appears to be wholly consistent, and no other will explain the upward movement of the objective. It proves conclusively the necessity of stiff and substantial tripod-legs.

The stability of a leveling instrument is necessarily somewhat affected by the distance of the telescope above the tripod-head. The condition of compactness should be kept in view, and the distance from the telescope to the tripod-head or lower parallel plate made as small as possible. It is evident that the form of leveling instrument shown in Fig. 2 conduces to greater stability than that shown in Fig. 3, the conditions of weight, material, and workmanship being equal.

The instruments shown in these two figures do not represent any particular makes, but they correspond somewhat to different styles that are manufactured by different firms. For an all-round leveling instrument, most engineers of experience prefer the type of construction shown in Fig. 2, on account of its compactness and consequent stability. This quality has been dwelt upon at some length. It is one of the most important requisites for a satisfactory leveling instrument, and can only be obtained by careful and accurate workmanship, with due regard to the conditions noticed above.

A clear and powerful telescope is also necessary. The magnifying-power should be sufficient for sighting the required distances; this qualification, however, will generally be found in the telescopes placed upon engineers' leveling instruments. The qualities which are more essential than high magnifying power, and in which telescopes are much more liable to be deficient, are *definition* and *light*. The size of the telescope, and, consequently, the focal length of its object-glass, is limited, so that high magnifying power is obtained only at a sacrifice of light. On this account many engineers choose telescopes having comparatively low magnifying power, preferring to sacrifice

some degree of power for the sake of good light, thus obtaining a telescope that can not only be used in poorer light, but will also show objects more clearly. The image of an object seen through a low-power telescope has a brilliancy never attained in telescopes of

Fig. 2.

higher power. With good light, however, the defining qualities of a high-power telescope may be all that can be desired.

It this connection, it may be well to notice the comparative merits of erecting and inverting telescopes. Most American engineers prefer telescopes showing the image of the object viewed erect, i. e., in its natural position. The object-glass of an ordinary telescope, however, always inverts, that is, it forms the image in an inverted position, or upside down; while the simplest and best form of eyepiece will simply magnify the image in the position as focused by the object-glass. Hence, with this form of

Fig. 3.

eyepiece the object is shown inverted. Such an eyepiece is composed of two lenses. If it is desired to show the image erect, or right side up, it becomes necessary to introduce two more lenses in the eyepiece, in order that it also shall be inverting; the effect of this is to reinvert the image to an erect position. Such eyepieces, though really inverting, are called *erecting* eyepieces, because they show the image erect; those composed of two lenses are called *inverting*, because they show the image inverted.

Thus it is seen that the erecting eyepiece is necessarily much longer than the inverting eyepiece and, for the same length of telescope, leaves correspondingly less length available for the focal length of the object-glass, besides cutting off more light by the two additional lenses. For the same length of telescope, and, consequently, for the same size of leveling instrument, the inverting telescope will not only have greater magnifying power, but will also show a more brilliant field than an erecting telescope. Indeed, in telescopes of the same magnifying power and focal length, the inverting telescope will show objects with greater brilliancy, on account of the amount of light gained by the omission of the two extra lenses in the eyepiece. In England, the inverting telescope is quite generally

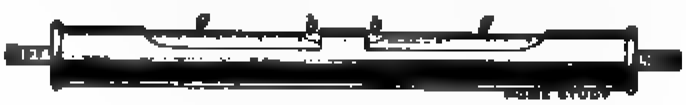


Fig. 4

preferred on leveling instruments. When the engineer becomes accustomed to viewing his rod in an inverted position, and to signaling upward when the desired movement of the target is apparently downward, and vice versa, he will find inverting telescopes generally more satisfactory than those showing objects erect.

Whether the telescope be of high or low magnifying power, or whether it show objects erect or inverted, it should be perfectly free from spherical and chromatic aberration. With reference to the former condition, the field of view should not appear spherical, but perfectly flat, and the objects viewed should not appear distorted in any manner. With reference to the latter condition, the telescope should be perfectly achromatic, so that a bright object viewed with a normal eye will be entirely free from fringes of color produced by the decomposition of light.

The *spirit-level* of a leveling instrument (see Fig. 4) should be accurate and sensitive. It is composed of a glass tube or vial so nearly filled with pure alcohol, ether, or similar fluid as to leave only a small bubble of air.

The glass vial is inclosed or mounted in a brass tube, for protection and in order that it may be attached to the leveling instrument. The upper portion of the tube is cut away at *g g*, so that the position of the air bubble *b b* can always be seen; but, in order to strengthen the tube, a small rib or bridge is left across the center of the aperture. The upper portion of the glass vial is graduated, so that the exact position of the bubble with reference to the center can be readily determined. In some instruments, a small metallic scale is placed above the vial; but this adds an amount of extra weight to the instrument which, though small, is wholly unnecessary. The best instruments generally have the graduations on the glass vial. The inside of the upper portion of the vial is ground truly to the arc of a circle, so that the movement of the air bubble shall be perfectly free and uniform. The sensitiveness of the bubble will depend upon the length of the radius of the arc to which the vial is ground, while the uniformity of its movement will depend upon the accuracy with which the glass is ground and the purity of the fluid contained in it. A sensitive spirit-level is much preferable to a sluggish one.

The accuracy of the spirit-level may be tested as follows: Level up the instrument, bringing the bubble exactly to the center, and sight at some distant, well-defined object which the horizontal cross-hair will exactly bisect. Derange the leveling-screws, and slightly agitate the fluid in the vial by revolving the instrument quickly or unevenly on its center. Again level up, and notice whether the cross-hair will bisect the same object exactly as before. If it will not, the fact indicates some defect in the spirit-level.

The conditions noticed above, namely, stability, a clear and sufficiently powerful telescope, and an accurate and sensitive spirit-level, are requisite to an accurate and satisfactory leveling instrument. All of these conditions should be carefully investigated when making a selection. An instrument may be accurate, however, and yet far from satisfactory. If it has a sensitive spirit-level, accurate work can generally be performed, even though the telescope-glasses be in some respects defective. Again, under favorable circumstances accurate work can be done with a very unstable instrument. But an unstable instrument or one with a defective telescope would be very unsatisfactory for general use. It would not only cause much annoyance, but also the loss of much valuable time.

A leveling instrument can only be made to fulfil all the required conditions by careful and accurate workmanship, and the use of the finest materials. It is impossible to judge wholly of these conditions in a new instrument, as the merits or defects do not become fully apparent until after considerable use. Much reliance, however, can be placed upon the general reputation of the instrument and maker. Unnecessary and unusual adjustments generally indicate defective workmanship. On the other hand, an instrument that exhibits superior qualities in any one respect is apt to be superior in other respects also.

HORNER'S METHOD.

George McC. Robson, M. A.

Failure of Algebraic Solution—Plagiarism—Horner's Method of Solving Numerical Equations—Bisection of Hemisphere—Extraction of Roots.

In mathematical and physical investigations, the result frequently depends on the solution of an equation. It is natural, therefore, that the solution of equations should have engaged the attention of mathematicians from an early period. A great department of mathematics, known as the *theory of equations*, has grown out of the attempts to discover general methods for the solution of equations of any degree.

An equation whose coefficients are letters is called a *literal* equation, and an equation whose coefficients are given numbers is called a *numerical* equation. Thus, (1) is a literal equation, and (2) is a numerical equation.

$$ax^2 + bx + c = 0. \qquad (1)$$

$$2x^2 - 15x + 25 = 0. \qquad (2)$$

Solving (1),

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}. \qquad (3)$$

Formula (3) is the general solution of the

quadratic equation, and the solution of any particular quadratic can be obtained from it by substituting for a, b, and c the numerical coefficients of that equation. Thus, the solution of (2) is found by putting $a = 2$, $b = -15$, and $c = 25$; whence,

$$x = \frac{15 \pm \sqrt{15^2 - 8 \times 25}}{4} = 5, \text{ or } 2\tfrac{1}{2}.$$

Mathematicians have long striven to obtain similar formulas for equations of higher degrees. Such results have been attained for equations of the third and of the fourth degree; but all attempts to arrive at similar general formulas for equations of the fifth or any higher degree have failed, and it is now established by the researches of Abel and others that such a solution of an equation of higher degree than the fourth is impossible. This failure, however, is not a matter of much regret, for it is seldom necessary to solve a literal equation. On the other hand, several excellent methods of solving numerical equations have been discovered; of these, the simplest and best is Horner's method, which is explained in this article.

The solution of the quadratic was known to the Arabians in the ninth century; in the eleventh century an Arabian algebraist published a classification of cubic equations with geometrical constructions, but without any attempt at a general solution. The study of algebra was introduced into Europe in the thirteenth century, and for a long period the Italians were the chief cultivators of the science. The earliest complete solution of the cubic is due to the Italian mathematician Tartaglia, who discovered it about the year 1535. He first shows how to reduce any cubic to the form

$$x^3 + 3mx + n = 0. \qquad (4)$$

He obtains the solution of this equation in the form

$$x = \sqrt[3]{p} - \frac{m}{\sqrt[3]{p}}, \qquad (5)$$

where $p = \frac{1}{2}(-n + \sqrt{n^2 + 4m^3})$. (6)

This solution is usually attributed to Cardan, who obtained it from Tartaglia by earnest solicitations, after having given the most sacred promises of secrecy. In spite of these solemn promises Cardan published it in 1545. Tartaglia began to publish his treatise in 1556, but died in 1559 before reaching the treatment of the cubic; his work, therefore, contains no mention of his own solution; hence, it has come to be regarded as Cardan's solution and is generally called by his name.

Suppose we attempt to use Cardan's formulas to solve

$$x^3 - 7n + 6 = 0. \qquad (7)$$

Comparing (7) with (4) we see that $n = 6$, and $m = -\frac{7}{3}$.

Therefore, by (6),

$$p = \tfrac{1}{2}\left[-6 + \sqrt{6^2 + 4(-\tfrac{7}{3})^3}\right] = \left(-3 + \frac{10}{3\sqrt{3}}\sqrt{-1}\right).$$

Hence, by (5),

$$x = \sqrt[3]{-3 + \frac{10}{3\sqrt{3}}\sqrt{-1}} + \frac{7}{3\sqrt[3]{-3 + \frac{10}{3\sqrt{3}}\sqrt{-1}}}. \qquad (8)$$

There is no general algebraic process for extracting the cube root of an expression like $\left(-3 + \frac{10}{3\sqrt{3}}\sqrt{-1}\right)$. Now, it is easy to see that the roots of (7) are 1, 2, and -3; hence, it appears that when the roots of the cubic are real, Cardan's formulas give a complicated imaginary result, which cannot be simplified by any algebraic process, though it can be simplified by means of trigonometry. Thus, though the formulas (5) and (6) contain a complete algebraic solution of the cubic (4), yet they cannot conveniently be employed to obtain the roots of a numerical equation. In the same way, the algebraic solutions of the equation of the fourth degree are unsatisfactory when applied to numerical examples. The conclusion of the whole matter is, that the algebraic solution of higher equations is practically valueless, even when it can be found.

Horner's method of solving numerical equations was first published in 1819; by this method the root is evolved figure by figure until the whole root is obtained if it is rational, or to as many decimal places as may be required if it is irrational. This method involves no algebraic profundity; its spirit is purely arithmetical, and it possesses all that exquisite simplicity that characterizes the fundamental rules of arithmetic. The calculation is sometimes laborious, but the process is just as simple as the ordinary method of extracting square root, to which it is exactly analogous. In order to give a clear exposition of Horner's method it is necessary to introduce some important definitions and demonstrate some preliminary propositions.

Any algebraic expression containing x is

called a *function* of x, and may conveniently be denoted by some such symbol as $f(x)$, or $F(x)$. Thus, if we are dealing with the two expressions $5x^3 + 6x^2 + 4x + 2$ and $3x^3 + 7x + 6$, we may write $f(x) = 5x^3 + 6x^2 + 4x + 2$ and $F(x) = 3x^3 + 7x + 6$. If we make $x = 10$, we have

$$f(10) = 5 \times 10^3 + 6 \times 10^2 + 4 \times 10 + 2 = 5642.$$

$$F(10) = 3 \times 10^3 + 0 \times 10^2 + 7 \times 10 + 6 = 3076.$$

It is important to distinguish carefully between two distinct kinds of equations which occur in algebra. The equation $x + 5 = 7$ can be true only on the condition that $x = 2$; such an equation is called a *conditional equation*, or an *equation of condition*. The equation $(x + a)(x + b) = x^2 + (a + b)x + ab$ is true whatever values may be assigned to a, b, and x; and the first member can be transformed into the second by performing the indicated multiplication. An equation whose first member can be transformed into the second by performing algebraic operations is called an *identical equation*, or an *identity;* and the two members are said to be identically equal. It can be proved that an identical equation involving x is satisfied by any value of x, and that the coefficients of x in the two members of such an equation are equal.

I. To find the quotient and remainder when a polynomial $f(x) = a_0x^n + a_1x^{n-1} + a_2x^{n-2} + \ldots + a_n$ is divided by $(x - h)$.

Let Q and R denote the quotient and remainder, respectively. Then,

$$f(x) = (x - h)Q + R. \qquad (9)$$

Clearly, the first term of the quotient is a_0x^{n-1}; hence, we may write

$$Q = a_0x^{n-1} + b_1x^{n-2} + b_2x^{n-3} + \ldots + b_{n-1}. \quad (10)$$

where $b_1, b_2, b_3 \ldots b_{n-1}$ are as yet undetermined. Substituting in (9) we get,

$$f(x) = (a_0x^{n-1} + b_1x^{n-2} + b_2x^{n-3} + \ldots + b_{n-1}) \times (x - h) + R; \text{ or,}$$

$$f(x) = a_0x^n + (b_1 - ha_0)x^{n-1} + (b_2 - hb_1)x^{n-2} + \ldots + R - hb_{n-1}. \qquad (11)$$

These expressions being identically equal, the coefficients of like powers of x in the two members must be equal; therefore,

$$a_0 = a_0,\ a_1 = b_1 - ha_0,\ a_2 = b_2 - hb_1, \ldots a_n = R - hb_{n-1}.$$

Hence, $b_1 = a_1 + ha_0$, $b_2 = a_2 + hb_1 \ldots R = a_n + hb_{n-1}$.

These equations determine the coefficients of the quotient and the remainder; the calculation is most conveniently arranged in the following form:

a_0	a_1	a_2	$a_3 \ldots$	a_{n-1}	a_n
	ha_0	hb_1	$hb_2 \ldots$	hb_{n-2}	hb_{n-1}
a_0	b_1	b_2	b_3	b_{n-1}	R

The first line contains the successive coefficients of $f(x)$; in writing down these coefficients care must be taken to supply the places of the coefficients of absent terms by ciphers. The third line contains the successive coefficients of the quotient and the remainder. The first term of the third line is a_0; the first term of the second line is obtained by multiplying a_0 by h; the product ha_0 is added to a_1 to obtain the second term b_1 of the third line; then b_1 is multiplied by h, and the product hb_1 placed under a_2, and added to it to obtain b_2, the third term in the third line. The repetition of this process furnishes all the terms of the third line, the last term being the remainder. The reader who desires to master Horner's method should perform some divisions by this method, verifying the result by ordinary division.

Divide $x^5 - 4x^4 + 7x^3 - 11x - 13$ by $(x - 5)$.

1	-4	$+7$	0	-11	-13
	5	5	60	300	1445
1	1	12	60	289	1432

Therefore, $Q = x^4 + x^3 + 12x^2 + 60x + 289$, and $R = 1432$.

II. To calculate the numerical value of a given function when any number is substituted for x.

Since equation (9) is an identity, it must be satisfied when any number whatever is substituted for x. Let $x = h$.

Then, $f(h) = (h - h)Q + R = R$.

Hence, $f(h)$ is equal to the remainder when $f(x)$ is divided by $(x - h)$. For example, find the value of $f(x) = 3x^4 - 4x^3 + 10x^2 + 11x - 61$, when x is equal to 2.

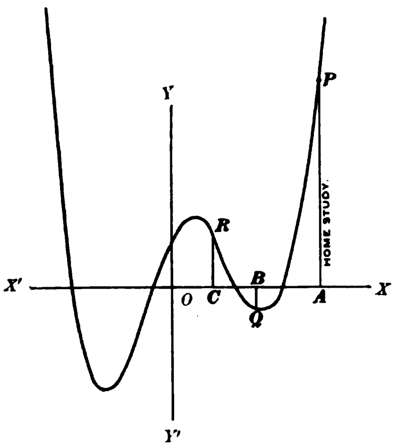
3	-4	10	11	-61
	6	4	28	78
3	2	14	39	17

Here $Q = 3x^3 + 2x^2 + 14x + 39$, and $R = f(2) = 17$. The reader can verify this result by actual substitution.

If we write $\quad y = f(x), \qquad (12)$

then, to any value of x will correspond a single value of y, and the relation between x and y can be represented to the eye by a curve. Let $X'OX$ and YOY' be two rectangular lines; lines measured on $X'X$ from O toward the right are positive, those measured toward the left are negative; lines measured from the line $X'X$ parallel to YY' are positive if they are measured upward, and negative if they are measured downward. Let any convenient length be taken

as unity. Then, any value of x, positive or negative, can be represented by a line measured on $X'X$ from the point O. Let any number a be represented by OA; calculate $f(a)$; from A draw AP parallel to OY, and lay off the length AP to represent $f(a)$. The point P lies above or below $X'X$ according as $f(a)$ is positive or negative. If the value of x varies continuously, the point P traces a continuous curve. In tracing the curve which represents a particular equation, it is well to begin by laying down the points corresponding to certain small integral values of x, positive and negative. It will then generally be possible to trace the curve with sufficient accuracy by joining these points by a line drawn free-hand. At the point where the curve cuts the line



$X'X$, we have $y = 0$; hence, the roots of the equation $f(x) = 0$ are represented by the distances from O to the points in which the curve intersects the line $X'X$.

III. If $f(a)$ and $f(b)$ have unlike signs, one plus and the other minus, then the equation $f(x) = 0$ has at least one real root intermediate in value between a and b.

The reader will recognize the truth of this important theorem by referring to the figure. Suppose $OA = a$, $OB = b$, $AP = f(a)$, and $BQ = f(b)$. If $f(a)$ and $f(b)$ have unlike signs, the points P and Q must lie on opposite sides of $X'X$; therefore, the curve joining these points must cut XX' at least once; that is, there must be at least one real root of the equation $f(x) = 0$ between a and b.

IV. To derive from the equation

$$f(x) = a_0x^n + a_1x^{n-1} + a_2x^{n-2} + \ldots + a_{n-1}x^n + a_n = 0 \qquad (13)$$

another equation, each of whose roots is m times a corresponding root of (13).

Let $y = mx$; then, $x = \frac{y}{m}$. Substituting this value for x in (13),

$$a_0\left(\frac{y}{m}\right)^n + a_1\left(\frac{y}{m}\right)^{n-1} + a_2\left(\frac{y}{m}\right)^{n-2} + \ldots + a_{n-1}\left(\frac{y}{m}\right) + a_n = 0.$$

Clearing of fractions,

$$a_0y^n + a_1my^{n-1} + a_2m^2y^{n-2} + \ldots + a_{n-1}m^{n-1}y + a_nm^n = 0. \qquad (14)$$

Since $y = mx$, each root of (14) is m times a corresponding root of (13). For example, the equation whose roots are 10 times those of the equation $3x^3 - 6x - 5 = 0$ is

$$3y^3 + 0 \times 10y^2 - 6 \times 10^2y - 5 \times 10^3 = 0,$$

or, $$3y^3 - 600y - 5000 = 0.$$

The equation whose roots are those of (13) with their signs changed is found by making $m = -1$ in (14); thus, the equation whose roots are those of (13) with their signs changed is

$$a_0y^n - a_1y^{n-1} + a_2y^{n-2} - \ldots + a_{n-1}(-1)^{n-1}y + (-1)^n a_n = 0. \qquad (15)$$

V. To derive from equation (13) another equation, each of whose roots is less by an amount h than a corresponding root of (13).

Let $y = x - h$; then, $x = y + h$. Substituting this value for x in (13), we get

$$a_0(y+h)^n + a_1(y+h)^{n-1} + a_2(y+h)^{n-2} + \ldots + a_{n-1}(y+h) + a_n = 0.$$

This equation can be arranged according to descending powers of y; we assume that when so arranged it becomes

$$A_0y^n + A_1y^{n-1} + A_2y^{n-2} + \ldots + A_{n-1}y + A_n = 0. \qquad (16)$$

The coefficients in (16) are as yet undetermined, but the method of division above explained affords a simple systematic method of calculating them. Putting $x - h$ for y, the left-hand member of (16) becomes

$$A_0(x-h)^n + A_1(x-h)^{n-1} + A_2(x-h)^{n-2} + \ldots + A_{n-1}(x-h) + A_n,$$

which must be identically equal to the left-hand member of (13). Hence, we have the identical equation

$$a_0x^n + a_1x^{n-1} + a_2x^{n-2} + \ldots + a_n = A_0(x-h)^n + A_1(x-h)^{n-1} + \ldots + A_{n-1}(x-h) + A_n. \qquad (17)$$

The results obtained by dividing the two members of (17) by $(x - h)$ must be identical. The first member of (17) is $f(x)$. Hence, A_n is the remainder when $f(x)$ is divided by $(x - h)$; A_{n-1} is the remainder when the integral quotient of the last division is divided by $(x - h)$; and so on. It is evident by examining (17) that $A_0 = a_0$. For example, diminish the roots of

$5x^3 - 11x^2 + 10x - 2 = 0$ by 3.

$$\begin{array}{cccc} 5 & -11 & 10 & -2 \\ & 15 & 12 & 66 \\ \hline 5 & 4 & 22 & 64 \end{array}$$

First quotient $= 5x^2 + 4x + 22$.
First remainder $= 64 = A_3$.

$$\begin{array}{ccc} 5 & 4 & 22 \\ & 15 & 57 \\ \hline 5 & 19 & 79 \end{array}$$

Second quotient $= 5x + 19$.
Second remainder $= 79 = A_2$.

$$\begin{array}{cc} 5 & 19 \\ & 15 \\ \hline 5 & 34 \end{array}$$

Third quotient $= 5 = a_0 = A_0$.
Third remainder $= 34 = A_1$.

Hence, the transformed equation is

$$5y^3 + 34y^2 + 79y + 64 = 0.$$

The calculation is written in the following form; since the first coefficient remains unchanged, it is not written at each step.

$$\begin{array}{cccc} 5 & -11 & 10 & -2 \\ & 15 & 12 & 66 \\ & \overline{4} & \overline{22} & \overline{64} \\ & 15 & 57 & \\ & \overline{19} & \overline{79} & \\ & 15 & & \\ & \overline{34} & & \end{array}$$

Transformed equation,

$$5y^3 + 34y^2 + 79y + 64 = 0.$$

VI. Comparing propositions II and IV, we see that $f(h)$ and A_n are each equal to the remainder when $f(x)$ is divided by $(x - h)$. Therefore,

$$f(h) = A_n. \qquad (18)$$

Putting $x = 0$ in (13) we get $f(0) = a_n$. (19)

VII. If there is no root of $f(x) = 0$ in the interval between 0 and h, then a_n and A_n must have the same sign. If $f(x) = 0$ has one, and only one, root between 0 and h, then a_n and A_n have unlike signs. This appears at once from a comparison of propositions III and VI.

VIII. If one of the roots of (13) is small, say between 0 and 1, then an approximate value of that root is $-\dfrac{a_n}{a_{n-1}}$.

For, by transposition,

$$a_{n-1}x = -a_n - a_0x^n - a_1x^{n-1} - a_2x^{n-2} - \ldots - a_{n-2}x^2.$$

Therefore,

$$x = -\frac{a_n}{a_{n-1}} - \frac{x^2}{a_{n-1}}(a_0x^{n-2} + a_1x^{n-3} + a_2x^{n-4} \ldots + a_{n-2}).$$

If x is small, an approximate value of x is found by neglecting x^2. Hence, $x = -\dfrac{a_n}{a_{n-1}}$, approximately. In the application of Horner's method to an equation whose root is small, this approximation is used to suggest the first figure of the root. Hence a_{n-1}, which is the second last coefficient, is called the *trial divisor*.

We are now in a position to expound Horner's method. When an equation has two roots so nearly equal that they commence with one or more like digits, the application of Horner's method to find these roots presents peculiar difficulties and requires special precautions. In practice, however, it is very rarely necessary to calculate such roots. Generally we can determine two numbers such that the equation has one, and only one, root intermediate in value between these two numbers; in this article we shall confine our attention to such equations.

Suppose the equation $f(x) = 0$ has a positive root 56.23. This root would be calculated by Horner's method as follows: First we determine that $f(x) = 0$ has one, and only one, root between 50 and 60; the first figure of this root is 5. Then, by proposition V, we diminish the roots of $f(x) = 0$ by 50, and thus obtain the first transformed equation $f_1(y) = 0$. If $f(x) = 0$ has no root between 0 and 50, the last term of $f(x)$ and the last term of $f_1(y)$ must have like signs; if $f(x) = 0$ has one, and only one, root between 0 and 50, the last term of $f(x)$ and the last term of $f_1(y)$ must have unlike signs. (Proposition VII.) The roots of $f_1(y) = 0$ are each less by 50 than a corresponding root of $f(x) = 0$; hence, $f_1(y) = 0$ has one, and only one, root between 0 and 10. By examining the signs of $f_1(y)$, for $y = 0$, $y = 1$, $y = 2$, . . . $y = 9$, we find that this root lies between 6 and 7. Therefore, the next figure of the root of the original equation is 6. We are usually spared the labor of examining the signs of $f_1(y)$ for all values of y from 0 to 9, by using the trial divisor (Proposition VIII) to suggest the next figure of the root. Having determined that 6 is the next figure, we diminish the roots of $f_1(y) = 0$ by 6, and obtain the second transformed equation $f_2(z) = 0$. Since $f_1(y)$ has no root between 0 and 6, the last terms of $f_1(y)$ and $f_2(z)$ must have like signs. (Proposition VII.) Hence, if the figure suggested by the trial divisor is too large, the error will show itself by causing the last term to change sign. If the figure suggested is too small, we shall discover the error on proceeding to calculate the next figure, which would exceed 9.

The second transformed equation $f_2(z) = 0$ has one, and only one, root between 0 and 1; to avoid the use of the decimal point we

multiply the roots of this equation by 10 (Proposition IV), and thus get an equation $f_2'(z')=0$, which has a root between 0 and 10. Proceeding in this way we find the root of $f(x)=0$, figure by figure. The figures suggested by the trial divisor become more and more reliable as the evolution of the root proceeds. The two essential conditions to be observed are: the sign of the last term must remain unchanged, unless when we pass over a root of $f(x)=0$, and each successive figure must come out not greater than 9.

However formidable this verbal description of Horner's method may appear, a careful examination of the following examples will render it clear to the reader. Suppose it is required to bisect a hemisphere whose radius is unity, by a plane parallel to the base; the distance of the bisecting plane from the center is given by the equation

$$F(x)=x^3-3x+1=0, \qquad (20)$$

or, $$x^3+0\times x^2-3x+1=0.$$

We proceed to solve this equation by Horner's method. In the first place, it is manifest that the distance of the plane from the center is less than the radius. Therefore, equation (20) must have a positive root less than unity. Multiplying the roots of (20) by 10 we get an equation

$$f(y)=y^3+10\times 0\times y^2$$
$$-3\times 10^2 y+1\times 10^3=0,$$

or, $$f(y)=y^3-300y+1000=0, \qquad (21)$$

which has a root between 0 and 10. Now, $(0)=1{,}000$, $f(1)=701$, $f(2)=408$, $f(3)=127$, $f(4)=-136$. Since $f(3)$ and $f(4)$ have unlike signs, $f(y)=0$ has a root between 3 and 4. (Proposition III.) The first figure of this root is 3. If we had used the trial divisor it would have suggested the first figure of the root correctly; for $\frac{1{,}000}{300}=3\frac{1}{3}$, so the figure suggested by the trial divisor is 3. The next step is to diminish the roots of $f(y)=0$ by 3.

1	0	− 300	1,000
	3	9	− 873
	3	− 291	127
	3	18	
	6	− 273	
	3		
	9		

Hence, the first transformed equation is

$$z^3+9z^2-273z+127=0, \qquad (22)$$

which has a root between 0 and 1. Multiplying the roots of this equation by 10,

$$z'^3+90z'^2-27300z'+127000=0. \quad (23)$$

The trial divisor of (23) is -27300. Hence, approximately, $z'=\frac{127000}{27300}=4+$ a fraction. This suggests 4 as the next figure. The next step is to diminish the roots of (23) by 4.

1	90	− 27300	127000
	4	376	− 107696
	94	− 26924	19304
	4	392	
	98	− 26532	
	4		
	102		

The second transformed equation is

$$w^3+102w^2-26532w+19304=0. \quad (24)$$

Multiplying its roots by 10,

$$w'^3+1020w'^2-2653200w'+19304000=0. \; (25)$$

The trial divisor of (25) is -2653200; and $\frac{19304000}{2653200}=7+$ a fraction, which gives 7 as the next figure.

The entire operation is written in the following form; the figures under the broken lines are the coefficients of the successive transformed equations:

			$x=.347+$
1	0	− 300	1000
	3	9	− 873
	3	291	127000
	3	18	− 107696
	6	− 27300	19304000
	3	376	− 18522077
	90	− 26924	781923
	4	392	
	94	− 2653200	
	4	7189	
	98	− 2646011	
	4	7238	
	1020	− 2638773	
	7		
	1027		
	7		
	1034		

Throughout this operation the two essential conditions for its accuracy have been fulfilled, namely, that the last term shall not change sign, and that each figure shall come out not greater than 9. By continuing the process we can get the root correct to as many decimal places as may be desired; to five places the result is $x=.34729$. Though the other two roots of (20) have nothing to do with the bisection of the hemisphere, we proceed to find them as an illustration of Horner's method. We have

$$F(x)=x^3-3x+1=0. \qquad (26)$$

Hence, $F(1)=-1$, $F(2)=3$.

Therefore this equation has a root between 1 and 2, of which the first figure is 1. When

we diminish the roots by 1, the last term changes its sign. This is an indication that we are passing over a root between 0 and 1. This is the root already found. The last term of the transformed equation is negative, and the minus-sign must be retained with the last term throughout the rest of the operation.

$x = 1.532+$

1	0	-3	1
	1	1	-2
	1	-2	-1000
	1	2	875
	2	0	-125000
	1	175	116577
	30	175	-8423000
	5	200	8063768
	35	37500	-359232
	5	1359	
	40	38859	
	5	1368	
	450	4022700	
	3	9184	
	453	4031884	
	3	9188	
	456	4041072	
	3		
	4590		
	2		
	4592		
	2		
	4594		
	2		
	4596		

Hence, the second root is $x = 1.532+$.

The third root is negative; to find it we derive from (20) another equation whose roots are equal to those of (20) with their signs changed. (Proposition IV.) This equation is

$$F_1(y) = y^3 - 3y - 1 = 0. \quad (27)$$

The positive root of this equation is numerically equal to the negative root of (20). Now, $F_1(0) = -1$, $F_1(1) = -3$, $F_1(2) = 1$. Therefore, $F_1(y) = 0$ has a root between 1 and 2. This root is found to be $y = 1.879+$. Therefore $x = -1.879+$.

The extraction of the nth root of any number N is equivalent to solving the equation $x^n - N = 0$. Hence, any root of a given number can be found by Horner's method. The method of extracting cube root commonly given in arithmetical text-books can be readily derived from Horner's method, but Horner's arrangement of the work is infinitely more simple than that adopted in arithmetics. Horner's arrangement covers a little more paper, but paper is cheap; and the reader will find that in every other respect Horner's method is superior. The complete solution of a "Horner" will be found in the answer to question 379 in the October number.

In these examples the root has been found to a few decimal places only; when it is necessary to obtain the root to a large number of decimal places, the last few figures can be determined with great facility by a contracted process, but we cannot enter upon the discussion of this contraction now.

POSITION OF MAXIMUM BENDING MOMENT.

Benj. F. La Rue.

FOR ANY SYSTEM OF QUIESCENT LOADS—WHAT SHEAR IS—HOW TO CONSTRUCT THE SHEAR DIAGRAM—POINT OF ZERO SHEAR AND MAXIMUM BENDING MOMENT.

IN ANY beam supporting a load or system of loads, there will exist stresses of different character. A beam simply supported upon two supports is called a *simple beam*. If a simple beam carry a load in the manner shown in Fig. 1, it will be subjected to direct longitudinal compression along its upper portion and direct longitudinal tension along its lower portion, while nearly all vertical cross-sections of the beam will also be subjected to a shearing stress. The compression of the upper fibers and extension of the lower fibers, taken together, are commonly called the *bending stress*. The bending stress is the stress produced by the bending moment upon the beam. Its effect in distorting or bending the beam is clearly shown in Fig. 1. In beams of *solid* cross-section, the bending stress is often the only stress considered, for the reason that, in such beams, the shearing stress will generally be abundantly resisted when the bending stress is sufficiently provided for.

Shearing stress is that stress which tends to rupture a solid body by causing any two portions to slide upon themselves, or tear.

A piece of pasteboard being cut by a pair of ordinary shears or scissors, is a good example of rupture being produced by a shearing stress. Another good example is that of a piece of iron being cut off by the great shears in an iron mill. The character of the stress producing rupture is the same in

Fig. 1.

either case. Rupture is produced along a section of the material by causing the two portions of the material on the opposite sides of the section to slide in the opposite directions with reference to each other. Machines and instruments producing this kind of rupture are commonly called shears and, from analogy, the character of stress producing it is called *shearing stress*, or, simply, *shear*.

In Fig. 1 is shown the tendency of the bending stress to distort or rupture the beam by bending, neglecting all consideration of shearing stress. In Fig. 2 is shown the tendency of the shearing stress to rupture the beam, under the same load, neglecting any consideration of bending stress. The load upon the beam tends to cause it to slide downward upon itself along a vertical section at each end of the load. It is very seldom that rupture will occur in a beam in the manner shown in Fig. 2, because bending stress will be present and will take a very important part in producing rupture. But, in the case of two pieces of iron bar riveted together, the rivet might shear out through the end of one bar, as

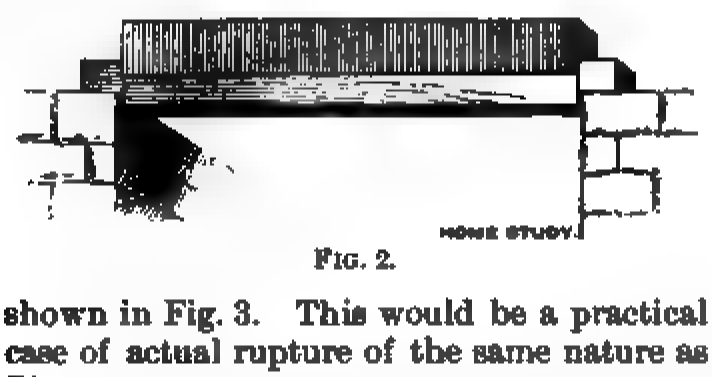


Fig. 2.

shown in Fig. 3. This would be a practical case of actual rupture of the same nature as Fig. 2.

It is thus seen that, in the case of any simple horizontal beam supporting a load or system of loads between two supports, stresses of two different kinds will exist, namely, horizontal bending stress, composed of tensile and compressive stresses, and vertical shearing stress. In reality, these two stresses, though of different characters, do not exist distinct and separate in the beam, but combine with each other, giving inclined resultants, which will have different inclinations at different sections of the beam. These resultants, however, are of such a complicated nature as to be very difficult of analysis, and, therefore, in analyzing the stresses in a beam, the horizontal bending stresses and vertical shearing stresses are considered separately.

In proportioning the material of a beam to resist the horizontal bending stresses upon it, the bending moment upon any required section of the beam is computed from the loading, and, as the resisting moment must be equal to the bending moment, the two expressions are placed equal, and, from the equation thus formed, the required dimensions of the beam are deduced. The shearing stress upon any section of a beam is resisted by the total unimpaired section.

Fig. 3.

Hence, having determined the dimensions of the beam necessary to resist the bending stresses at any section, it is only necessary to multiply the total amount of unimpaired section, in square inches, by the allowed shearing stress per square inch, and compare the result with the shearing stress upon the section, in order to ascertain if the section of the beam be sufficient to resist the shearing stress.

As most ordinary beams are of uniform cross-section, it is necessary to determine only the *maximum* bending moment and *maximum* shearing stress upon them, in order to proportion their dimensions. For, if the beam is uniformly of a cross-section sufficient to resist the maximum stress upon it, it will evidently be of sufficient strength to resist any smaller stress. In proportioning the material for the ordinary beam, therefore, the first important step is to determine the amount of the maximum bending moment and of the maximum shear. It is easy to determine the amount of the maximum bending moment, if we

know at what point along the beam it occurs; if we cannot first determine at what point along the beam the maximum bending moment occurs, however, it will be necessary to compute the bending moments at all points along the beam, in order to determine its maximum value. The same is true also of the shear. It is quite possible, however, to determine the points along a beam at which will occur the maximum shear and bending moment, due to the load, or system of loads, upon it. How to do this will now be explained.

The manner in which the shearing stress is distributed along a beam may be plainly illustrated by what is called a *shear diagram.* In Fig. 4 is represented a simple beam supporting a system of three loads A, B, and C of 400, 1,000, and 800 pounds, respectively, as shown. Below the beam is shown the shear diagram for the system of loads. In constructing the shear diagram, the loads A, B, and C are first laid off in order, to any convenient scale, upon the vertical line passing through the left reaction R_1, as the loads *0-1*, *1-2* and *2-3*. This is called the *load line.* The amount of the two reactions R_1 and R_2 may be calculated by means of moments, and also laid off in the corresponding order upon the load line, as *3-m* and *m-0*. Through the two extremities of each load, as thus laid off upon the load line, horizontal lines are drawn to the right, intersecting the vertical line through the corresponding load, as situated upon the beam. The horizontal lines *0-a* and *1-b*, *1-c* and *2-e*, *2-f* and *3-g* are such lines. The two horizontal lines drawn through each intermediate point on the load line will coincide throughout the length of the shorter line. The last line, through the bottom of the load line, is extended to intersect the vertical through the right-hand reaction R_2 at the point h. Also, the horizontal line $m\ n$ is drawn through the point m on the load line, where the extremities of the two reactions meet, as laid off upon the load line.

The broken line $0\ a\ b\ c\ e\ f\ g\ h$, thus constructed, is called the *shear line*, and the horizontal line $m\ n$ is called the *shear axis.* The shaded figure $0\ n\ h\ m$, included between the shear line and shear axis, is called the *shear diagram.* The shear diagram shows at a glance the relative amounts of the shear at all points along the beam. Where the shear upon the beam is of such character as to tend to cause that portion of the beam at the left of any vertical section to slide or shear upward along the section, and the portion at the right of the section to shear downward, the shear is, for convenience, called *positive shear.* Likewise, where the shear is of such character as to tend to cause the portion of the beam at the left of any section to shear downward, and the portion at the right of the section to shear upward, the shear is said to be *negative shear.* Thus, in Fig. 2, the shear represented as occurring at the left-hand end of the load is positive shear and that at the right-hand end is negative shear. Where the shear diagram, constructed as above, lies above the shear axis $m\ n$, it represents positive shear, and where it lies below the shear axis it represents negative shear.

At any point, the amount above or below the shear axis represented by the shear

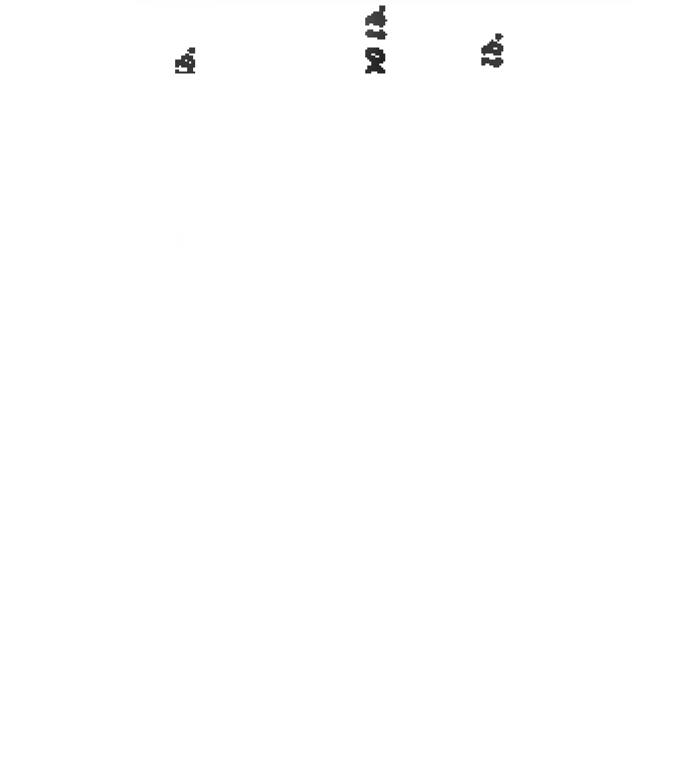


FIG. 4.

diagram, to the scale used for the load line, will be the amount of positive and negative shear along the beam. Thus, referring to Fig. 4, at all points between the left reaction R_1 and the load A, the beam sustains an amount of positive shear equal to $m\,0$, or the left reaction R_1 = 1,000 pounds. At all points between the loads A and B, the beam sustains an amount of positive shear equal to $m\,0$, minus *0-1*, or the reaction R_1 minus the load $A = 1{,}000 - 400 = 600$ pounds. At all points between the loads B and C, the beam sustains an amount of *negative* shear equal to *m-2*, that is, equal to the reaction $m\,0$ minus the loads *0-1* and *1-2* or the reaction R_1 minus the loads $(A + B) = 1{,}000 - (400 + 1{,}000) = -400$ pounds. Likewise, at all points between the load C and the reaction R_2, the beam sustains an amount of negative shear equal to *m-3*, that

is, equal to the reaction $m0$ minus the combined loads *0-3*, or the reaction R_1 minus the loads $(A + B + C) = 1.000 - (400 + 1,000 + 800) = - 1,200$ pounds. The negative shear between the last load C, and the right reaction R_2 is thus found to be equal to the right reaction.

From the above explanation it will be noticed that, in computing the shear at any point along the beam, the process is simply that of subtracting the aggregate amount of the loads between that point and the left reaction, from the left reaction. Or the process may be considered as adding algebraically the loads and reaction at the left of the point, considering the reaction as positive and the loads as negative. The process is very simple and will always give the shear correctly.

It will be noticed that for a simple beam *the maximum amounts of positive and negative shear will occur at the respective reactions, and, in each case, will be uniform at all points between each reaction and the adjacent load.* It will also be noticed that the amount of shear changes under each load and is uniform between the loads. At any load, the amount of shear may be considered to be the same as the amount on either side of the load, or it may be given any value between those amounts.

At some load, the shear will pass from positive to negative. In Fig. 4 this change occurs under the load B. At this load, the shear passes from $1,000 - 400 = 600$ pounds to $1,000 - (400 + 1,000) = -400$ pounds, and may be considered to be of any amount between these limits. Evidently, in passing from a value of 600 pounds to a value of -400 pounds, the shear must become zero. It is important to notice and thoroughly understand this fact, for *at that section of the beam where the shear becomes zero, the maximum bending moment will occur.*

This is a well-established and important principle. It affords the means of readily determining the position at which the maximum bending moment will occur in a simple beam, under any system of quiescent loads, for the point of zero shear is always easily found. From an inspection of the shear diagram of Fig. 4, it will be noticed that the shear becomes zero at that point where the sum of the loads between the point and the reaction becomes equal to the reaction. This sum of the loads will include some portion of the load under which the zero shear occurs. The left reaction and the sum of the loads at the left of the point, or the right reaction and the sum of the loads at the right of the point may be considered; it is customary, however, to consider the loads and reaction at the left of the point. The point or section of zero shear will also be the position at which the maximum bending moment occurs. This principle is important and may be stated as follows:

The maximum bending moment in a simple beam, produced by any system of quiescent loads, will occur at that point where the sum of the loads at the left (including, if necessary, a portion of the load directly at the point) equals the left reaction.

As a further aid in determining the position of the maximum bending moment, it should be noticed that, as the amount of shear changes only at a load, it can pass to or through zero only under a load. Hence, *the maximum bending moment must always occur under a load.* It will be well to notice, however, that in a beam supporting an even number of loads, and symmetrically loaded with reference to the center of the beam, the shear may be zero under each of the two center loads and at all points between them. In such a case, also, the bending moment will be maximum at each of the two loads and uniformly maximum at all points between them. This is no exception to the principle stated above; it is simply a special case in which the zero shear and maximum bending moment occur under two loads, instead of under one load only.

The principle that the maximum bending moment will always occur under a load and at the point of zero shear, enables us to at once determine the position of the maximum bending moment for any system of quiescent loads. Having determined the position of the section at which the maximum bending moment occurs, the amount of the bending moment can be readily calculated. Thus, for the system of loads shown in Fig. 4, it is found that the point of zero shear, and, consequently, of maximum bending moment, occurs under the load B. The amount of this bending moment is $1,000 \times 8 - 400 \times 5 = 6,000$ foot-pounds. This is the maximum bending moment upon the beam. For, at a section one foot to the left of the load B, the amount of the bending moment is $1,000 \times 7 - 400 \times 4 = 5,400$ foot-pounds, and, at a section one foot to the right of the load B, the amount of the bending moment is $1,000 \times 9 - 400 \times 6 - 1,000 \times 1 = 5,600$ foot-pounds, showing that the bending moment diminishes in each direction from the load B.

BEET-SUGAR.

George F. Lord.

How Sugar is Made From Beets—Preparing the Beets—The Slicer—The Diffusion-Battery—Purifying and Filtering the Juice—Boiling Down and Granulating.

NOT many years ago the world's supply of sugar was obtained almost entirely from the sugar-cane ; not because sugar did not exist in any other vegetable growth, but because no economical means could be devised for its extraction. Nearly all ripe fruits and vegetables contain sugar, and it is found in considerable quantities in the sap of the maple-tree, sweet corn, and the sugar-beet.

In 1747, Marggraf, a German chemist, succeeded in obtaining sugar from beets, but his method was too expensive to be practical, and various experiments were conducted by different scientific men with a view to simplifying the process. It was not until the beginning of the present century, however, that beet-sugar became an article of commercial importance. Since then its manufacture has increased to such an extent that more beet-sugar is used to-day than cane-sugar.

In the year 1896 we imported 1,670,963 tons of refined sugar, at an expense of $89,219,773, while in the year 1894 we paid $126,871,889 for imported sugar. It is small wonder, then, that such wide-spread interest has been felt in the establishment of beet-sugar factories in this country. The business has now passed beyond the experimental stage, and it has not only been demonstrated that we can raise the beets, but also that we can produce the finest quality of sugar from them.

While all beets contain sugar, the largest percentage is found in a white variety, known as the "sugar-beet." This beet contains from 10 to 20 per cent. of sugar; varying with the soil, climate, and manner of cultivation. The farmer who raises the beets trims off all the green stalks and upper part, as they contain an alkaline juice which would prevent the crystallization of the sugar. The trimmed beets are then hauled or shipped to the factory. Here they are weighed by an official weighman, and the farmer receives for them about $5.00 per ton. The beets arrive at the factory in wagons, railway-cars, and canal-boats, and are dumped upon the ground. The beets that the farmer has overlooked are trimmed, and all are then thrown into a trough which runs through the yard. The stream of water in the trough is about 6 inches deep ; it carries the beets to the factory-building, washing off considerable dirt on the way. At the rear of the building they fall into the end of an inclined trough which contains a spiral conveyor. This carries the beets upwards, allowing the dirt and water to drain away, and drops them into what are called *double washers.*

These consist of two large, cylindrical tanks, mounted horizontally, and partly filled with water. The beets enter at the right of the first washer and are rolled around by a number of radiating paddles, which slowly work them towards the left end. Here they leave the first washer and enter the second. They are then rolled in a similar manner back to the right, where they pass under a stream of clean water and fall into the buckets of an endless chain.

The cleaned beets are carried by these buckets up to the top of the building, and dumped into the "slicer." Here they fall against revolving V-shaped knives, which cut them into long strings of about ¼-inch square section. One man is kept continually at work sharpening knives for this machine, as they dull very rapidly. After slicing, the pieces fall into a swivel-chute, so arranged that it may be readily directed towards any of the tanks which make up the "diffusion-battery."

This consists of 12 tanks about 10 feet deep and 3 feet 6 inches in diameter, which are partly filled with the sliced beets, and sealed up. The slices are then covered with scalding water, and subjected to a steam-pressure of 40 pounds to the square inch. This pressure is sufficient to force the water through the sugar-cells of the beets. Here it takes up the sugar, and is drawn off as a thin syrup, of about the same sweetness as maple-sap. This operation is repeated several times with each lot of slices, in order to get as much of the sugar as possible ; but about 2 per cent. of sweetness remains in

the pulp. This pulp is then squeezed dry, and dumped into the yard, to be sold to farmers for feeding to cattle. It is quite sweet and agreeable to the taste.

Having obtained the syrup, it becomes necessary to immediately purify it and boil it down, as it will not keep well after separation from the beet. So it is next piped to the "carbonization-tanks." Here it is mixed with milk of lime, made from the lime-kiln on the grounds. This milk of lime is necessary for the clarifying of the syrup, but must be removed again, as its presence would prevent crystallization. It is first precipitated by the action of carbonic acid gas, which is also obtained from the lime-kiln. The syrup is then piped to another part of the building, and passes through large filter-presses. These presses consist of a number of iron frames, upon which are stretched large cloth screens. The screens permit the passage of the syrup, but the carbonate of lime is deposited between them. At regular intervals the presses are opened and the solid matter scraped away from the cloths. It falls into a pit, and is sold to the farmer for fertilizer.

The syrup is now nearly pure, but has a yellowish color. So it is piped up to tanks on the top floor and then allowed to trickle down over screens to another set of filters. In passing over the screens, it meets with the fumes of burning sulphur, and is bleached. The last set of filters remove any impurities which have escaped the first set, and the syrup passes to the "vacuum-boilers."

These are arranged consecutively—three in a row, commonly called "the triple effect"—and are heated by steam at the base. The air and vapors from the syrup are drawn off by pumping and condensation, until nearly all pressure is removed, and the syrup boils at a very low temperature. This is necessary to prevent loss of sugar and discoloration of the product. It is very interesting to look into the sight-holes and notice how freely the syrup boils on account of the reduced pressure above it. The syrup passes in turn through each of the three boilers, and leaves them much thicker than when it entered. It is next piped to the "sugar-boiler."

A small quantity of syrup is introduced into this boiler and allowed to reach a certain stage of crystallization, when it is "fed" with more syrup by an experienced operator. This is a most important part of the operation; and the man in charge neither sees nor hears anything that does not pertain to the work itself. The product of this boiler is known as "masse-cuite," and contains a large percentage of sugar crystals, mixed with molasses. From the boiler it passes to the "sugar-mixer," where it is stirred up by a revolving screw, and then let down into the "centrifugal machine."

This machine consists essentially of a deep cylindrical pan about 4 feet in diameter, which contains an inner cylinder, the wall of which is a brass screen. The masse-cuite falls into this inner compartment, which is then revolved by a vertical shaft, at the rate of 1,200 revolutions per minute. The molasses is thrown into the outer compartment by centrifugal force, and the sugar, white and clean, remains in the center. The molasses and uncrystallized sugar is drawn off into a storeroom, where it is kept warm for about 6 weeks. It is then run through again, and more white and brown sugar obtained from it. When one is looking at the black, slimy mess in this room, it is difficult to realize that sugar can be obtained from it; but such is the case.

From the centrifugal machine, the white sugar is carried to the sugar-box. Here the writer saw a young man standing in a large box containing over 6 tons of sugar, which he was slowly shoveling into a chute that led to the granulator. The sugar, as it leaves the centrifugal machines, is damp and lumpy. The granulator is for the purpose of drying it and separating it into crystals. It looks very much like a steam-boiler about 30 feet long, slightly inclined from the horizontal and revolving slowly. Through the interior a blast of hot air is blowing, which carries off all the moisture, and the rolling of the huge cylinder breaks the sugar up into small crystals.

Directly underneath the mouth of the granulator, on the next floor, are the scales. Sacks are placed on the platform, the chute is opened, and out comes a stream of white sugar, which, 24 hours before, was lying out in the yard in the hearts of some dirty beets. As the sugar falls into the sack, it is inspected by the state inspector, and each sack is stamped: "100 lb. of sugar," with the name of the inspector, the factory, and the date.

The Department of Agriculture is encouraging the extension of beet-sugar manufacture by many experiments and the free distribution of seeds. In New York State, the manufacturer receives a bounty on all

sugar which reaches the required standard of purity, and this enables him to pay the farmer more for his beets.

At the present time, capitalists in New York State are planning the erection of factories in several localities. Sample lots of beets, grown in many states, show a high percentage of sugar, and there is no longer any doubt in the minds of well-informed men that the United States can become independent of other sugar-producing countries, provided the capitalist and the farmer unite their forces to attain this end. In the sugar-beet we may have the new crop for which the farmer has been looking, as its successful cultivation would undoubtedly put farming on a paying basis, and enhance the value of land.

LOGARITHMS.

Extract from a letter received from W. H. Booth, of London, England.

IN Mr. McC. Robson's interesting account of the inventor of logarithms, John Napier, of Merchiston, there are one or two points on which a little further information may be welcome. In my own library is a book on which I set considerable store. It was published in the year 1633, which was only nineteen years after Napier's first publication of his invention of logarithms. It is written in that quaint phraseology of which the trace still remains in legal documents. Though I do not use the book much, because it is tender with age, it contains what is to-day the most convenient and best arranged table of logarithms which I possess. After the title-page comes a preface "wherein the reader shall finde necessarie directions for the use of the ensuing Tables." The author then proceeds to state that "The noble invention of *Logarithme* is rightly attributed to the noble Author and Inventor thereof *John Neper* Baron of *Merchiston* in Scotland." Reference is then made to the "*Baron* of *Merchiston* having laid the foundation of this invention and (*in anno* 1614) published the same to the World." It appears that a famous mathematician of the time, "Henry Brigges then professor of *Geometry* in *Gresham Colledge* in London," perceived the great value of the invention, and "as soone as his leasure and the season of the yeare would permit," he journeyed into Scotland to "conferre" with the Baron. It was at this visit that the two mathematicians resolved upon the present form of logarithms. Full directions are given in the book for using the tables in finding the "logarithmes" of fractions and of a *Decimall*, and throughout the whole table every logarithm is printed with its "characteristique," the logarithm with the characteristic comprising eight figures. They are, in fact, what are known as seven-figure logarithms. The second part of the book contains the logarithms of the sines and tangents of every degree of the quadrant, each degree being divided into 100 parts or "centesmes." It thus appears that the somewhat novel system of decimals had taken hold of men's minds so far that they published logarithmic tables in which the old sexagesimal division of the degree was ignored. The volume closes with a short account of the use of logarithms in "Geometrie, Astronomie, Geographie and Navigation." The book only measures 7″ x 4½″ x 1″. I have found a few obvious misprints, while at some time or other a small book-maggot has eaten a little hole from the title-page as far as the page containing the number 18,000, etc. The title-page describes the book as TVVO TABLES of Logarithms, and gives the author as Nathaniel Roe, Pastor of Benacre in SVFFOLKE. At the foot of the page is the imprint: London. Printed by M. Flesher for Philemon Stephens and Christopher Meredith at the Golden Lion in Paul's Churchyard, MDCXXXIII.

The beauty of this old table of logarithms lies very much in the style of the figures employed. Unlike most modern figures they are not of the same height. The 0 and the 1 and 2 are much of a height and stand on the same base level. The 3 is a much taller figure and stands above and below the aforesaid imaginary lines. The vertical line of the 4 comes well below the line, and 5, 7, and 9 are tail figures coming well below the line. Figure 8 stands on the line, but is as high a figure as 3 and stands up higher than the top of 6. This style of figure, which is reproduced in part in a modern table I have, is very much easier to read correctly than the even-sized modern figures of parallel height we find in most books of to-day. The old figures have a better individuality.

DAINTY DESSERTS.*

Mrs. Henry Esmond.

DAINTY DISHES ARE NOT ALWAYS WHOLESOME—SOME THAT ARE—PRUNES IN JELLY— CHOCOLATE PUDDING—TAPIOCA AND FRUIT—STALE-CAKE CUSTARD AND PUDDING.

IT IS often very hard to think of some dessert that is simple and yet wholesome—something out of the general run of puddings and pies. The writer has found the following desserts very delicate and a pleasant change:

Prunes in Jelly.—Wash 1 pound of prunes; soak over night in cold water. In the morning put them in a stone crock on the back of the stove where they will stew slowly but not boil. In 2 hours remove them from the fire and strain the liquor off into a bowl. Let the prunes cool and then remove the pits; this is easily done by pinching the prune with the fingers. The pit will come out of the stem-end without breaking the rest of the prune. There should be from 2½ to 3 cups of liquor in which the prunes have been cooked; to this add ¾ cup of sugar and and a little less than ½ box of gelatine, the gelatine having been soaked in a little cold water until it is very soft. Stir until the sugar and gelatine are all dissolved. Pour into an open dish and mix in the prunes and stand in a cold place to stiffen. Serve with whipped cream, which has been sweetened with a little sugar and flavored with vanilla. This dessert is very easily prepared and is not only delicious but very wholesome.

Chocolate Pudding.—Break 2 squares of Baker's bitter chocolate into small pieces and put it in a bowl on the top of the hot-water kettle, to melt. Scald 3 cups of milk; beat the yolks of 4 eggs; add ½ cup of granulated sugar. When the milk is scalded, pour part of it over the chocolate and stir until it is well mixed; then pour back into the remainder of the milk, and stir slowly into the eggs. When well mixed strain into a buttered baking-dish and flavor with 1 teaspoonful of vanilla. Set the dish in a pan of hot water in a hot oven. The reason for putting the dish in hot water is, that the custard is not so apt to separate as when it is put in the oven without the water underneath. Bake about 20 minntes, or until a knife, stuck into the center of the pudding, comes out clean. Beat the whites of the 4 eggs quite stiff; add 1 teaspoonful of sugar for each white, and a very little vanilla. Pile on top of the pudding and set back in the oven. Let it get a very delicate brown. This pudding is better if made the day before it is to be served. In cooling anything like prune pudding, lemon pie, or any dish which has meringue on top, never remove it from the oven to a very cold place, as the sudden cooling makes the egg-mixture fall. First, let it stand in the kitchen until partially cool, then put it outdoors or in the refrigerator.

Tapioca and Fruit.—Soak ½ cup of pearl tapioca for 2 hours in cold water, enough to cover it. Put into a double boiler and pour over it 2 cups of hot water. Let it cook until it is a transparent jelly; remove from the fire and stir into it 2 cups of either raspberry- or blackberry-jam. Pour into a bowl and let it cool. Serve with sugar and cream. Fresh peaches, strawberries, and oranges may be used as well. Rice is delicious prepared in the same way.

Stale Cake and Custard.—Cut stale sponge-cake into slices ½ inch thick; arrange in a dish and pour over it a custard made in the following manner: Scald 2 cups of milk in a double boiler; beat 2 eggs slightly and add 4 tablespoonfuls of sugar and a pinch of salt; pour the scalded milk onto the eggs, stirring constantly to prevent lumping; return to the double boiler and stir until it

* In November last we published the first of a series of five articles on "The Cooking of Wholesome Meals." We have been pleased to receive, during the past few months, many complimentary criticisms of the clear manner in which the receipts were explained. There has been one exception, however, to the otherwise uniformly favorable criticisms: we had a letter from the West the other day in which one of our readers suggested, in all friendliness, that few of our subscribers are ever likely to become either professional or amateur cooks, and that, therefore, in devoting a page to the subject of cooking we were deliberately throwing away a one-page opportunity to do good. It is therefore, perhaps, as well to again remind our scientific readers that these articles are not for them but for their friends and relatives of the fair sex, and we make bold to start afresh with "Dainty Dishes."—ED.

thickens, being careful that the eggs do not separate; remove from the fire and let cool; when cool, flavor with ½ teaspoonful of vanilla; pour this custard over the cake and serve with or without whipped cream, as preferred. A little brandy or sherry, poured over the cake before the custard is added, is a great improvement. Any kind of plain stale cake may be used, though sponge-cake is probably the best. When a custard separates, pour it immediately into a cold bowl and beat it vigorously with the egg-beater. If it is not too badly separated this will bring it back to a smooth custard again. Custard is not so apt to separate when cooked in a double-boiler, as when the saucepan is put directly over the hot stove. If you have no double boiler, a bowl or small pail, set in a pan of hot water, is a very good substitute. It answers the purpose and is less expensive.

Stale-Cake Pudding.—Another very nice way of preparing stale cake is to make a pudding of it. In making this, use only spice- or fruit-cake. Cut it into slices about ½ inch thick, and put it into a white cloth in a steamer over hot water. If you have no steamer use a cullender instead, and set it on the top of the hot-water kettle. When the cake is thoroughly steamed, but not soggy, remove to a hot dish. Serve with a liquid sauce, which may be made in the following manner: Boil 1 cup of water and ½ cup of sugar together; add 2 tablespoonfuls of flour (mixed to a smooth paste with a little cold water) and 1 tablespoonful of butter; beat hard to prevent lumping and, when clear, remove from the fire. Just before serving add 2 tablespoonfuls of brandy and a little grated nutmeg. If you prefer it, add the grated rind and juice of one lemon. Sour-grape jelly is a very nice substitute for brandy.

CURRENT TOPICS.

Mrs. F. R. Honey.

The Seals of Behring Sea.

THE fur seal, *Callorhinus ursinus*, has been a somewhat conspicuous figure upon the world's stage during the last few years. He has received attention from three great modern governments, the United States, Great Britain, and Russia; commissions of eminent jurists and statesmen have considered his case; world-renowned naturalists have visited his haunts, and studied his habits; ardent jingoes have threatened war on his account. He has been wittily described as a "hardy annual," so continually recurrent is he as a factor in international politics; and some of those who are interested commercially in him—and his skin—have even proposed, as a solution of all difficulties connected with him, that the species should be exterminated by wholesale slaughter in his breeding places.

We call him the seal of Behring Sea. This term suggests the happy mean between the ideas of the extremists, some of whom regard him as the seal of the Pribyloff, or of the Commander Islands, and the private property, in the first place, of the countries to which those islands belong, and in the second place, of the companies which lease them; and others believe he is the seal of the Pacific Ocean, one of the great hunting-fields of sea-faring sportsmen, and, therefore, the common property of the human race. The reports made on him by jurists and by naturalists have been as divergent in character as are those two views of his ownership, and "who shall decide when doctors disagree?"

The habits of the fur seal, which incidentally have brought it into this prominent position, are in some respects unique among mammalia. He is amphibious, dividing his time almost equally between land and water, but seeking his food entirely in the latter element. He also possesses the mysterious migratory instinct, which, twice a year, at a certain season, impels him to travel long distances either to his winter or his summer home. He directs his course to a small group of rocky islets in the Behring Sea and steering with unerring accuracy, he journeys for more than 3,000 miles, from the latitude of California to the Pribyloff Islands, which lie in the midst of that shallow, stormy, and foggy region. Or, the herds which spend the winter months off

the coasts of Japan, settle for the summer on the Commander Islands, on the Russian side of the Behring Sea.

The Pribyloff group includes two islands, St. Paul and St. George, and two rocks named the Otter and the Walrus. These islands, generally shrouded in fog, are of volcanic origin, bleak and barren, with precipitous cliffs, the home of innumerable wild-fowl. The line of cliffs is broken here and there by flat beaches. These are the "rookeries," or breeding-places of the fur seal, and here the curious habits peculiar to this species can be observed. Their spring journey is made in orderly fashion. About May 1st the bulls (the old males) arrive at the islands, and each selects a spot on which to settle himself and family for the summer. Sharp conflicts take place between them for the most desirable spaces, which are those along the shore front, and the younger and milder and weaker of the tribe have to be content with "rear lots." As soon as the bulls are established, the young males, the bachelor seals, called holluschickies, and the yearling females put in an appearance. They, however, are not allowed on the "rookeries," but must confine themselves to inland spots known as the "hauling grounds," where they need not intrude on the business or the pleasure of their elders.

Ere long the mature females appear on the scene. The bulls are on the watch for them, and each takes possession of as many as he can secure, to the number of 10 or 15, or even 30, and guards his family closely on the spot of ground which he has chosen. Fights between the bulls are of constant occurrence at this juncture, and the victor will often take possession of the entire harem of the vanquished. Within a few days of the arrival of the females the young are born, and are nourished by their mothers at intervals of two or three days, until, at three months of age, they begin to swim and to seek food. The mother goes out to sea about twice a week, and may swim from fifty to a hundred miles in search of fish, but the male never leaves his chosen spot of ground, and takes neither food nor drink for a period of from three to four months. His extraordinary power of sustaining existence without nourishment for so long a time is the more remarkable in view of the fact that his life is not spent in sleep, like that of the hibernating animals, but is one of constant exercise and of sleepless vigilance. He is perpetually on the watch to protect his family and to keep them within their alloted bounds, which often include a space of not more than one hundred square feet, the size of a very small room. Acres of ground are solidly packed with these families, divided only by narrow paths which are kept clear and distinct, yet the female returning from her quest for food goes straight to her destination, without attempting to stray into strange territory.

The parental instinct is less strongly developed in the female than in the male seal. She will desert her pups on the slightest alarm, while the bulls will fight savagely if need be. They do not fear man, nor attack him without provocation, and this makes the capture of those that are to be killed for the sake of their skins an easy matter. The victims are selected from amongst the young males, the bachelor seals, and preferably from those that are from two to four years old. This section of the herd goes to sea once in seven or ten days, and at other times occupies its hauling grounds, sleeping, or playing, or quarreling, filling the air now and then with a booming sound. Like all other seals, they detest the sunshine, and the moist, foggy atmosphere which pervades these islands is exactly suited to their needs. A journey of even a few hundred yards, over quite dry ground, distresses them and makes them weak and faint.

During the month of June, July, and October the fur is of better quality than at any other time, so then the poor seals receive their death sentence. The natives of the islands, who are employed for this purpose, drive small herds of the young males about a mile inland, and there despatch them. The number which may be taken each year is fixed by agreement with the leasing company, and as a bull-seal has from 15 to 30 wives, about 14 out of 15 of the young males may be taken for commercial purposes without permanently diminishing the size of the herd. In October and November the seals set forth on their journey to the southern waters, and the islands are left for the winter to the swarms of sea-fowl, and to the few score of natives, who are descendants of the Aleuts, taken there as colonists by the Russian government in 1786.

It is evident that during the months of their land sojourn the seals can be treated almost as if they were domestic animals. A certain proportion can be chosen for slaughter exactly as sheep and oxen are selected for the market, and if they were taken at no other time and in no other way, the herd might

increase and multiply at the will of the owners of the islands, and yet supply all the sealskins which the markets of the world will take, at whatever price the company might choose to fix. But while the seals are out hunting for food or are passing back and forth through the Pacific Ocean they are fair game for the first comer, and it need hardly be said that under these circumstances no selection can be made, nor can any discrimination as to age or sex be exercised. The seal resting on the ocean swell, or coming to the surface for a few moments to breathe, may be old or young, male or female. If it be the latter, an unborn pup may be destroyed with the mother, or she may have left on the beach her young, which will perish of hunger for want of their natural food. If wounded, the seal generally dives out of reach, and even those which are killed at the first shot, sometimes sink. It is believed by some that not more than one, out of every four or five seals shot at sea, is recovered.

In view of these facts—if facts they be—it is easy to see that the extermination of the seal may be only a matter of time, and this is the indictment brought against the advocates of pelagic, or ocean, sealing. The nations interested in the matter have agreed on a "close season," during which no seals may be killed anywhere, but those who can control the Pribyloff and the Commander Islands wish to have the killing of seals limited to those spots where they congregate, and thus ensure the preservation of a valuable species. Incidentally, such a regulation would ensure to the two countries, and practically to a few individuals, the bulk of the profits arising from a very useful natural product, for the trade in sealskins would become a monopoly in the hands of the companies which control the two groups of islands. Naturally, Americans and Canadians who have invested capital in outfits for pelagic sealing, object to a restriction which would result only in loss to them, and only in gain to their rivals.

Utopian conditions of unselfishness and international disinterestedness are hardly to be looked for in a world where the struggle for existence is hard, and at a time when competition of all kinds is keen. In Utopia, if it ever could have been or ever is to exist, those conditions of life will be modified and simplified. For the present all those who believe that the lion may one day lie down with the lamb, believe, also, that this will only come about when the lamb is inside the lion! That is, it will not be until Might has asserted and proved its customary supremacy over Right; or, perhaps, its identity with the real, actual, and true "Right"; for the view of the case will differ according to the optimism or the pessimism of the observer.

And if the fur seal should be exterminated for purposes of commerce it will only go the way, alas! of many another valuable species. Where are the herds of buffalo which used to range over American plains? Where are the troops of "big game," lions, elephants, and giraffes which used to make Africa a paradise for hunters? According to Mr. Bryce, who has recently visited their country, they too are rapidly disappearing. Such appears to be the inevitable fate of wild animals which are of great value to man, and which are spread over too wide an area for it to be possible to protect them by continual care and watchfulness, unless like some kinds of fishes they increase and multiply by the million.

But the large section of the population which is interested in the preservation of the seal from the point of view of the consumer, rather than from that of the producer, may be consoled by recalling the history of the beaver, which, less than a century ago, was supposed to be doomed to extermination, so large was the number of skins used annually for commercial purposes. Dame Fashion, often roundly abused as an extravagant and frivolous mistress, went into partnership with the ingenious inventor; they stepped in and saved the beaver. Silk, and another kind of fur were substituted for his skin in the manufacture of hats; and who would now wear the heavy, old-fashioned beaver hat or bonnet in preference to the articles used to-day? In consequence of the falling-off in the demand for the skins, the beaver was less closely pursued, and soon returned to such of his haunts as had not been occupied by man, and there is now an amply abundant supply to meet all demands for his fine and beautiful fur. Who knows but that some such change may take place with regard to the now admired and highly prized sealskin? And when it becomes superannuated we shall wonder why three nations allowed themselves to be disturbed about the future of the seal in this last decade of the nineteenth century.

(110) I want to make a U-shaped crank-shaft as in the accompanying sketch (Fig. 1), using 2-inch square iron. How shall I set about making the bends nice and square, and with as little metal as possible?
W. L. C., Owensboro, Ky

ANS.—We would advise you not to make it out of square iron and not to use square corners, especially at *a*, *a*. Why not make it out of round bar, with easy

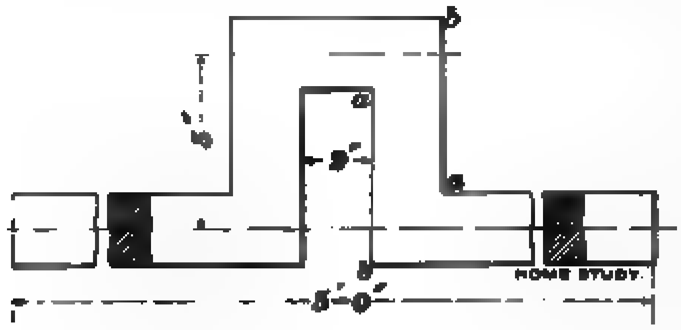


FIG. 1.

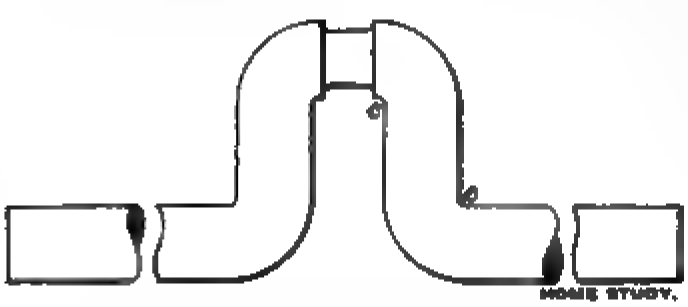


FIG. 2.

bends, as in Fig. 2? Considerable labor will be thus saved, and you will have good, safe fillets at *c*, *c*. If, however, you use the square iron and wish to have square corners at *b*, *b* you will have to weld pieces on at these points; and at *a*, *a* you must cut the metal away to secure the squareness you desire.

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(111) I wish to establish a small amateur shop, a Home Manual Training School, for my two boys, 10 and 6 years old. I have a very good, cabinet maker's bench and shall add a lathe very soon. I wish to start with making useful household articles, picture frames, boxes, stools, etc. (*a*) Where can I buy a set of good cabinet maker's tools for a rational price? (*b*) Where shall I buy the lathe? (*c*) What books can you recommend from which to learn how to work wood (also carving, polishing, etc.,) with working drawings? (*d*) What books can you recommend for lathe-work (wood), with working drawings?
G. A. C., Philadelphia, Pa.

ANS.—(*a*) Montgomery Tool Co., Fulton Street, New York. (*b*) Seneca Falls Mfg. Co., 695 Water Street, Seneca Falls, N. Y.; W. F. Short and John Barnes Co., 436 Ruby Street, Rockford, Ill. (*c*) Exercises in Woodworking, Ivan D. Sickels, Appleton & Co., N. Y. Wood Carving for Amateurs, by Denning, Comstock, N. Y. (*d*) A Manual of the Hand-Lathe, by Watson, published by Comstock, N. Y.

(112) The enclosed drawing represents a $3\frac{1}{4}'' \times 1\frac{1}{4}''$ water-motor for running a dynamo or other small machine. (*a*) Do you think the construction is practical? (*b*) Where would you advise me to put the discharge-pipe? (*c*) What power should such a motor develop at 40 lb. pressure? (*d*) What should be the size of the inlet- and discharge-pipes? (*e*) What kind of metal should the motor be made of?
B. R. W., Bridgeport, Conn.

ANS.—The construction of your motor is such that it would develop very little power under any conditions; therefore, it would have no practical value for driving machinery. There will be an article on Impulse Water-Wheels in the May issue of this Magazine.

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(113) Is there any reason why a gauge-glass should break after being cleaned? The one in question was 1" in diameter and 6" long and was used to record the height of water above a dam; it was cleaned out with a piece of waste attached to copper wire. When the water was let into it again, it broke about 1" below the top of the water. It had been in use about one year.
F. S. H., Manchester, N. H.

ANS.—If you had used a steel wire for cleaning and scratched the glass at the point mentioned, the subsequent breakage would perhaps admit of explanation. As, however, you merely used copper wire, this could not have happened. Did you use hot water when cleaning it and so cause a small crack that escaped your notice at the time?

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(114) Please give full directions how to work division by means of "Napier's Bones," described in January number of HOME STUDY MAGAZINE in the article entitled "Napier."
W. K., Wheeling, W. Va.

ANS.—Suppose it is required to divide 1,046,775 by 2,463. First select the bones (*a*), (*b*), (*c*), and (*d*) whose top figures give the divisor, and arrange them as in Fig. 4 (reproduced here). The first figure of the quotient is 4, and

2463 | 1046775 | 425
9852
6157
4926
12315
12315

the fourth row gives the partial product $2,463 \times 4 = 9,852$. Subtract this from the dividend, and bring down 7. The next figure in the quotient is 2, and the second row gives the partial product $2,463 \times 2 = 4,926$. Subtract this from the dividend, and bring down 5. The last figure in the quotient is 5, and the fifth row gives $2,463 \times 5 = 12,315$. Thus, the "bones" give us the partial products, and we perform the subtractions in the ordinary way.

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see advertising page IV.

(115) (*a*) What are the approximate proportions of chimney-gases, by volume and weight, under the condition of perfect combustion? (*b*) If too much air is admitted to the fire what effect will it have, and what gas will be produced in largest quantities? (*c*) What proportion of the gas so produced is allowable in good practice? J. B. F., Cincinnati, O.

ANS.—(*a*) With an average grade of dry bituminous coal, the composition of the chimney-gases, if just the theoretical amount of air required for perfect combustion were used, would be about as follows:

	By weight.	By volume
Nitrogen	70.7	79
Carbonic acid	25.6	18
Water	3.7	3

(*b*) The effect of admitting more air to the fire than is required for perfect combustion is a lowering of the temperature of the fire. The quantity of nitrogen in the chimney-gases is increased in direct proportion to the increased quantity of air admitted, and all the oxygen above what is required for perfect combustion of the fuel passes to the chimney in a free state. These gases must be heated in passing through the furnace, and the heat remaining in them when they enter the chimney is lost. (*c*) Perfect combustion cannot be obtained without admitting more than the theoretical quantity of air. It is usual to provide for the use of about twice the theoretical amount required.

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(116) I am thinking of making a simple mercurial barometer. Please instruct me how to do so. I understand that it is very difficult to obtain a perfect vacuum above the mercury and that the mercury has to be boiled. Is a simple mercurial barometer of any practical use in foretelling the weather?
J. W. A., Newport, R. I.

ANS.—The glass tube is filled with mercury, and the air and moisture are expelled by boiling the mercury in the tube. The open end is then placed in a vessel of mercury and the closed end is raised until the tube is vertical. The barometer gives general indications regarding the state of the weather. The barometric height measures the weight of the atmosphere; as a rule the atmosphere is lighter, and the barometer lower, in stormy weather, but this is not necessarily the case.

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(117) Regarding gas-engines of the two-cycle type: (*a*) Is the Day type considered as good as the Otto? (*b*) To what proportion of the stroke should the gas mixture be compressed before explosion? (*c*) The cylinder of a gas-engine is 4 inches in diameter, and the stroke is 5 inches; what is the power of the engine, and (*d*) what should be the areas of the exhaust- and admission-ports, and (*e*) should the admission-port begin to open just after exhaust and at the very end of stroke? (*f*) What should be the thickness of water-jacket? (*g*) What should be the diameter and weight of the balance-wheel for a 4″ x 5″ engine?
G. A. S., Boston, Mass.

ANS. (*a*) We see no reason why it should not be just as good if well made. (*b*) One-half for flame ignition; one-third for electric or tube ignition. (*c*) 2½ nominal horsepower Day type. (*d*) Exhaust-port 2 square inches, admission-port 1½ square inches. (*e*) The exhaust-port should be wide open before the admission-port begins to open. This refers, of course, to the Day type. (*f*) ⅛ inch to ¼ inch. (*g*) 2 fly-wheels, each 20 inches diameter, with rims 2½ inches wide on face and 2¾ inches deep. They will weigh about 100 lb. each.

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(118) Will you kindly give a diagram showing how the development of the plate necessary to form a connection at the point where a 36-inch cylinder connects to a 48-inch cylinder at an angle of 60°? The material is ¼ inch thick.
H. M. L., Pottstown, Pa.

ANS.—Draw center lines *ab* and *bc* (Fig. 2) at the given angle to each other, and the center line *ad* perpendicular to *ab*. Add about three-eighths of the thickness of the metal to the inside radius for drawing the construction lines, all in inches. In this case, these construction radii will be $\frac{48 - (2 \times \frac{1}{4})}{2} = 23\frac{3}{4}$ inches = inside radius of the larger cylinder, and $23\frac{3}{4} + (\frac{3}{8} \times \frac{1}{4}) = 23\frac{27}{32}$ inches = construction radius *ad*; and $\frac{36 - (2 \times \frac{1}{4})}{2} = 17\frac{3}{4}$ inches = inside radius of the smaller cylinder, and $17\frac{3}{4} + (\frac{3}{8} \times \frac{1}{4}) = 17\frac{27}{32}$ inches = construction radius *ef*. Describe the quadrant *gd* in the plan *A*, and the semicircle *f 4 g* in the full view *C*. Draw the diameter *feg* perpendicular to *bc*. Divide the semicircle *f 4 g* into eight or more equal parts, as *1, 2, 3*, etc. Draw parallels to *bc* through *f* and all the numbered points, as shown, to the elevation *B*. Set off on *ab* from *a* all the distances of the points *1, 2, 3*, etc., from *fe* and number them the same.

FIG. 1.

From these points draw parallels to *ad* intersecting *dg*, and from these intersections draw parallels to *ab* intersecting the parallels to *cb* from the other numbered points. A line *f′-1-2*, etc., through these intersections is a side elevation of the joint. Draw *f″ch′* perpendicular to *bc* and make *cf″* and *ch′* each equal to one-quarter the length of a circle with radius *ef*. In this case this is

$$\frac{2 \times 17\frac{27}{32} \times 3.1416}{4} = 28.03 \text{ inches.}$$

Divide *f″h′* the same as the semicircle *fg*, and number the points of division in the same order

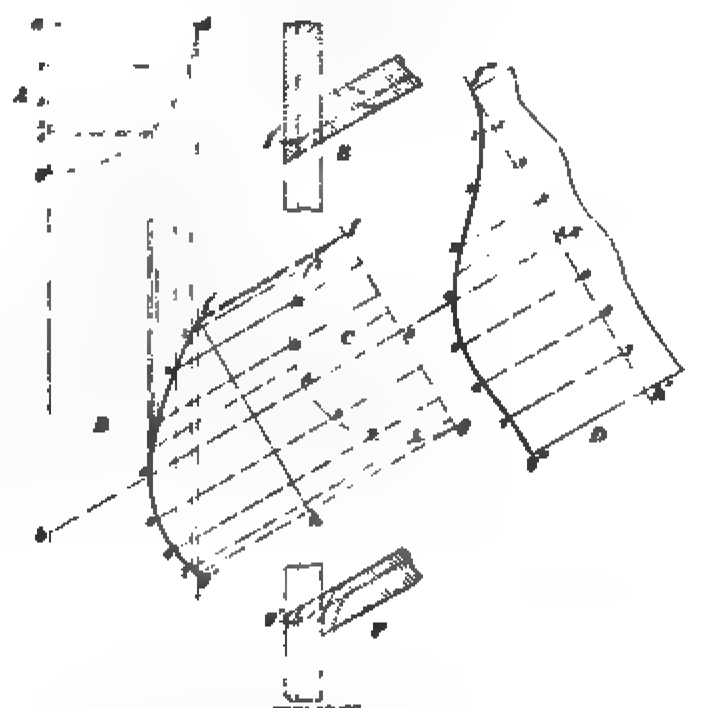

FIG. 2.

1, 2, 3, etc. Draw parallels to *ec* through these points and set off on them from *f″h′* the same distances that the intersections *1, 2, 3*, etc. in the elevation *B* are from *f′h*. Draw the line *f″g″* through these points. In places where this line has short bends an intermediate point may be found, as shown. Fig. *D* is one-half of the required development and *h′g″* is its center line. The length of the branch is added on the other side of *f″h′* as indicated, and the

flange is added on the outside of $f'' g''$, but in adding the flange it must be observed that $f'' g''$ is an ideal joint-line, the real joint being a little inside of f'' and g'', as illustrated by the full-size sections E and F, which also show the manner of allowing for the flange.

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(119) In the enclosed figure $A B + B C = 150$; $A C = 45$; $A D = 50$. Find $A B$, $B C$, and $C D$. If possible, solve the problem by trigonometry.

F. G. E., Union Bridge, Md.

ANS.—From the triangle $A B C$,

$$\frac{\sin A + \sin C}{\sin B} = \frac{a + c}{b} = \frac{150}{45} = \frac{10}{3}. \qquad (1)$$

From the triangle $A D C$,

$$\frac{\sin C}{\sin\left(\frac{\pi}{2} - B\right)} = \frac{\sin C}{\cos B} = \frac{A D}{A C} = \frac{50}{45} = \frac{10}{9}. \qquad (2)$$

From (1),

$$\frac{\sin A + \sin C}{\sin B} = \frac{2 \sin\left(\frac{A + C}{2}\right) \cos \frac{A - C}{2}}{2 \sin \frac{A + C}{2} \cos \frac{A + C}{2}} = \frac{\cos \frac{A - C}{2}}{\cos \frac{A + C}{2}} = \frac{10}{3}.$$

Therefore,

$$\frac{\cos \frac{A}{2} \cos \frac{C}{2} + \sin \frac{A}{2} \sin \frac{C}{2}}{\cos \frac{A}{2} \cos \frac{C}{2} - \sin \frac{A}{2} \sin \frac{C}{2}} = \frac{1 + \tan \frac{A}{2} \tan \frac{C}{2}}{1 - \tan \frac{A}{2} \tan \frac{C}{2}} = \frac{10}{3}.$$

Therefore, $$\tan \frac{A}{2} \tan \frac{C}{2} = \frac{10 - 3}{10 + 3} = \frac{7}{13}. \qquad (3)$$

Again, we have $$\frac{\cos \frac{A - C}{2}}{\cos \frac{A + C}{2}} = \frac{10}{3}.$$

Therefore,

$$\frac{2 \cos \frac{A - C}{2} \cos \frac{A + C}{2}}{2 \cos^2 \frac{A + C}{2}} = \frac{\cos A + \cos C}{1 + \cos(A + C)} = \frac{10}{3}.$$

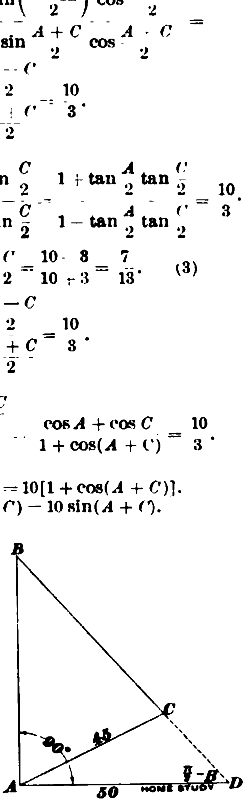
Hence, $3(\cos A + \cos C) = 10[1 + \cos(A + C)]$.
From (1), $3(\sin A + \sin C) = 10 \sin(A + C)$.
Squaring and adding, $9(2 + 2 \cos A \cos C + 2 \sin A \sin C) = 200 + 200 \cos(A + C)$. Transforming,

$91 \cos A \cos C - 109 \sin A \sin C + 91 = 0$. (4)

From (2) we get,

$10 \cos A \cos C - 10 \sin A \sin C + 9 \sin C = 0$. (5)

Eliminating A between (4) and (5), we get $324{,}000 \sin^4 C - 294{,}840 \sin^3 C + 638{,}361 \sin^2 C - 1{,}490{,}580 \sin C + 828{,}100 = 0$. (6)



This equation will be found to have a root between .91 and .92, and another root between .92 and 1. By Horner's method the former root is found to be, $\sin C = .9137773$; hence, $C = 66° \, 1' \, 57.7''$. From (3) we get $A = 79° \, 17' \, 34.9''$; from (2), $B = 34° \, 40' \, 27.4''$. Therefore, $A B = 72.2785$, $B C = 77.7215$, $B D = 87.8873$, and $C D = 10.1658$.

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(120) (*a*) Suppose that Herod's crown had been an alloy of silver and gold and weighed 22 ounces in air and $22\frac{1}{2}$ ounces in water, what would the proportion of each metal have been? (*b*) Can steam be generated in a boiler that is *closed* and *full* of water?

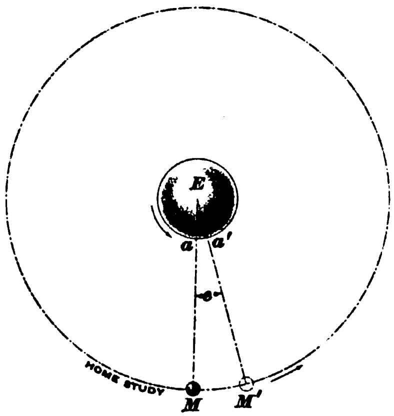
A. H. G., Clyde. O.

ANS.—(*a*) As a body weighs less in water than in air, we suppose you meant to say the weight of the crown was 22.5 ounces in air and 22 ounces in water; but even so, the problem is impossible, as will be seen by the formulas below. The formulas, however, are perfectly general, and can be applied to all problems of this kind. A similar problem led Archimedes to the discovery of the laws of floating bodies (see HOME STUDY MAGAZINE, Sept. 1897, article "Eureka!"). Assume that there is no difference between volume of alloy and sum of volumes of its constituent elements, and let P_a and P_w be the weights of the crown in air and in water, respectively, G the weight of the gold, S the weight of the silver, g and s the specific gravities of gold and silver, and W ounces the weight of unit-volume of water. Then, weight of unit-volume of gold $= Wg$, and volume of G ounces of gold $= \frac{G}{Wg}$. Likewise, volume of S ounces of silver $= \frac{S}{Ws}$. Therefore, volume of crown $= \frac{G}{Wg} + \frac{S}{Ws}$. Now, weight of water displaced $= P_a - P_w$, and its volume $= \frac{P_a - P_w}{W}$, which, equated to volume of crown, gives $\frac{G}{Wg} + \frac{S}{Ws} = \frac{P_a - P_w}{W}$; or, canceling common factor $\frac{1}{W}$, and replacing S by $P_a - G$, $\frac{G}{g} + \frac{P_a - G}{s} = P_a - P_w$, whence, $G = \frac{[P_a - (P_a - P_w)s]g}{g - s}$. In like manner we find $S = \frac{[(P_a - P_w)g - P_a]s}{g - s}$. These formulas show that the problem is impossible when P_a is either smaller than $(P_a - P_w)s$, or greater than $(P_a - P_w)g$; in other words, the ratio $\frac{P_a}{P_a - P_w}$ must lie between s and g; otherwise the formulas give negative results, which indicate that the conditions stated in the problem are contradictory. In the present case $P_a = 22.5$, $P_w = 22$, $g = 19.5$, $s = 10.5$, and $\frac{P_a}{P_a - P_w} = \frac{22.5}{.5} = 45$, which being greater than g, or 19.5, shows that the problem is impossible. (*b*) There is, for every liquid, a temperature, called the *critical temperature*, above which the liquid cannot remain in its liquid state, but is changed into a gas, whatever the pressure. This has been established by experiment; but it is evident that in all cases that can be studied experimentally, the liquid does not originally fill the vessel entirely, and, consequently, there is some space for steam to begin to form. After some time, the pressure of the steam formed is so great, that vaporization ceases; but, by continuing to increase the temperature, an instant is reached at which the whole liquid suddenly disappears, being converted into steam; this happens when the liquid attains its critical temperature. Although nothing can be said with certainty of what would happen under imaginary conditions, it seems probable that, in the case of a hermetically closed and inexpansible boiler filled with water, the latter would remain liquid up to the critical temperature (about 700°) and then be instantly vaporized, or, rather, acquire the properties of a gas, for at such temperature there would be no distinction between the liquid and the gaseous states. If the boiler were neither inexpansible nor *unburstable*, it would burst under the pressure of the liquid water before the critical temperature was reached, but no steam would be formed.

(121) (*a*) What power will be evolved by a Corliss engine whose cylinder is 22 inches; stroke, 42 inches; revolutions, 88 per minute, and boiler pressure, 90 pounds per square inch? (*b*) What am I to understand by the phrase "a *uniformity* of the moon's journey around the earth," when in its onward or forward motion through half its orbit, its speed, to gain one hour in the twenty-four (24) and keep pace, must be *accelerated*, and in its retrograde, or backward movement, during the other half of the lunar month, must be *retarded*? T. T. V., Frackville, Pa.

ANS.—(*a*) Assuming that cut-off occurs at ¼-stroke, and that the back pressure is 3 pounds per square inch, the mean effective pressure is about 54 pounds per square inch. The horsepower on this assumption is $\frac{54 \times \frac{42}{12} \times .7854 \times 22^2 \times 2 \times 88}{33,000} = 383$ H. P. nearly.

(*b*) The motion of the moon, relative to the earth, may be understood by reference to the accompanying diagram: *E* is the earth and *M* the moon. The earth rotates on its axis in the direction shown by the arrow, and the moon moves in its orbit also counter-clock-wise, as shown. Now, suppose that at a given



time, say 9 o'clock, the moon is directly above a point *a* on the earth's surface; in 24 hours the point *a* will be in the same position again, and if the moon in the meantime had stood still, it would again be directly above *a* at 9 o'clock. The moon, however, has, during these 24 hours, moved to *M'*, so that the point *a* has to move to *a'* before it is again under the moon. Let *e* be the angle *M E M'* between the successive positions of the moon. Then, in 24 hours and a little more the earth has moved through the angle $360° + e$ while the moon has moved through the angle *e*. But the earth makes 29.53 revolutions while the moon makes one; hence $\frac{360° + e}{e} = 29.53$, or, $e = \frac{360°}{28.53}$. The earth moves through a degree in 4 minutes; therefore, to move from *a* to *a'* requires $\frac{360 \times 4}{28.53} = 50\frac{1}{2}$ minutes. That is, the moon, on an average, rises 50½ minutes later every day throughout the month. The moon's motion around the earth is practically uniform.

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(122) (*a*) What are the chemicals that are used in developing and fixing the ordinary dry plates? (*b*) What is the composition of the toning and fixing solutions used by photographers? (*c*) Can you tell me of a good book on amateur photography? A. D, L., Kansas City, Mo.

ANS.—(*a*) Any chemical that will precipitate metallic silver from its bromide and iodide salts, will have a developing action on photographic plates. These salts are very numerous and each photographer has his favorites for each particular purpose. Among the most popular of these chemicals are hydroquinone and metol, either of which, when combined with some alkali such as sulphite of soda, will form a very powerful developer. Hydroquinone development produces a negative which has great contrasts in light and shade, with little detail in the shadows, and is, therefore, used where drawings or engravings are to be copied and black lines on a dead white ground are wanted in the resulting print. Metol, on the contrary, gives a negative of little contrast, showing great detail in the deepest shadows, and is a valuable developer for portrait work and instantaneous views, but for ordinary work it is apt to produce thin negatives, which will not give satisfactory prints. A combination of the two can be made which will be all that is desired for a developer of general-view work, the one giving density and contrast, and the other productive of detail. Packages of dry plates, manufactured for the trade, always contain formulas for various developers, and additional information is always cheerfully given by the manufacturers or dealers. After development the plate is fixed by immersion in a 25 per cent. solution of hyposulphite of soda until all the silver salts unacted upon by the developer are dissolved, a condition which can be readily determined by examining the back of the plate, as all whiteness will then have disappeared. (*b*) After prints have been made from a negative they may be toned in a solution of chloride of gold, varying in its strength from one to two grains of gold in 16 oz. of water made alkaline by the addition of a little borax. Various toning formulas accompany all brands of printing papers. The prints are then fixed in a solution of hyposulphite of soda, similar to the one used for plates. (*c*) "First Step in Photography" and "Second Step in Photography," by Dundas Todd (Editor Photo. Beacon), Chicago, Ill.

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(123) Would it require as much heat to raise steam at a pressure of 80 pounds above the atmosphere on top of a high mountain as it would at sea-level? Please give full explanation. V. E. P., Kalo, Iowa.

ANS.—The boiling-point of water depends on the external pressure acting upon it; consequently, all subsequent pressure-points are affected by a change of external pressure. At the sea-level the average atmospheric pressure is 14.7 pounds per square inch, which corresponds to a barometric reading of 30 inches. As the external pressure decreases, the boiling-point of water decreases, that is, less heat is required to boil it. Consequently, on a high mountain less heat is required to convert and raise water to steam of any desired pressure. Steam of 80 pounds gauge (94.7 absolute) has a temperature of about 323.56° F. at sea-level, whereas on a mountain 11,000 feet high (above sea-level) where the atmospheric pressure is only 9.8 pounds per square inch, with the barometer at 20 inches, steam at 80 pounds gauge (89.8 pounds absolute) would have a temperature of only 319.86° F., so that in this case less heat would be needed to obtain the required steam pressure.

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(124) What is a good way to put babbitt metal on brass and iron? What kind of acid should be used, strong or weak? M. N. F., Terre Haute, Ind.

ANS.—The chief point to be observed when babbitting is to get a clean face, free from grease, especially when metalling flat surfaces, that is, where the metal is not held in recesses. Make a solution, in water, of sal ammoniac, and apply to the parts with a brush. Make the articles hot; apply the above flux; tin the surfaces well, and then pour on the babbitt, working it evenly all over the surface with a

flat stick, and also into the recesses, if there are any. When the metal is set you may give it a sharp pounding with your ball-peen and so work it tightly into the recesses. When dealing with cast iron—such as guide-blocks, eccentric-straps, axle-boxes, etc.—some people prefer to use muriatic acid, killed with zinc, as the sal ammoniac rusts the iron.

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(125) I have received a copy of the "Mechanics' Pocket Memoranda," published by The Colliery Engineer Company, and notice upon the cover a curious optical illusion, which I have before this observed upon the covers of other books bound in dull-finished morocco or black velvet, and stamped with lettering in gold-leaf. If I hold the book about 15 inches from the eye, and in such position that the refraction from the gold-leaf lettering is directly towards me, the letters appear to be raised about ⅛ inch above the surface of the leather, and to be entirely separate from it. I have noticed that the extent and deceptive quality of this illusion depends upon the brightness of the lettering and the dull or dead finish of the leather or velvet. If the lettering is very bright and the leather or velvet has no luster whatever, the letters will appear to be from ¼ inch to ½ inch away from the surface upon which they are impressed, almost inducing one to believe that a card could be slipped between the letters and the cover of the book, the letters being thus lifted from their place. Please explain the philosophy of this illusion, which, I think, will interest many of your readers.

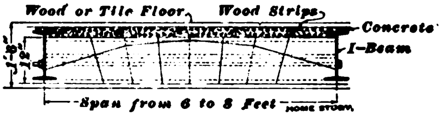
H. L., Scranton, Pa.

ANS.—The illusion referred to is produced by the reflex action of the eye of the observer. The eye focuses a point instinctively, that is, without the conscious exercise of the will, and therefore the action is truly reflex. On looking at a series of figures on a map, you are not conscious in doing so that you do not see any of them with precision, until you try to look distinctly at a word, and then all the figures on the map become invisible, and even if you try to look distinctly at one letter in a word, the rest of the letters in that word become somewhat less distinct. Again, if you look distinctly at the point over the letter *i* you will not see with equal precision the letter to which it belongs. The reason for all this is due to the fact that for the eye to see the figures on an extended surface, the optic lens must sweep over the field of view with great rapidity to find, instead of a single focus, a multiple focus. The phenomenon you refer to arises in this way: You hold the book in such a position that the bright gold letters are a blaze of light. When the surface on which the letters lie is a dull black, the eye is perplexed, and under the guidance of its reflex action tries to focus a line of points that are more remote than the letters, because a dull black surface generates a feeling, if it may be so called, of exaggerated distance. A dull black surface presents no points for the eye to focus upon. If we need proof of this we have only to look into the mouth of a dark cave in a mountain side. The dull black opening leads the mind to imagine great depth. If we close our eyes we get the same effect. But we are able immediately to focus the letters on the dull black surface of the book cover, and we have, therefore, two opposing effects—the dull black giving the idea of depth and distance, and the bright letters focusing at a *definite* distance from the eye. The natural result is an appearance of appreciable space between the letters and the book cover. The dark seances given by conjurers depend upon what we have attempted to explain. A black dull curtain—of velvet, we believe—is hung at the back of the stage, and from the flies, and from above project other black velvet screens. The stage then looks like a dark, empty vault. A face, hand, or arm thrust through a hole in the curtain can be illumined by a side light without any background being rendered visible, and the mysterious dark seance results.

(126) How would you calculate the thrust or tension in a tie rod for a flat, hollow, tile-floor arch as shown in sketch enclosed? If formula $T = \frac{1.5\,W\,L^2}{R}$ given in Carnegie's hand-book is used, how would you determine R? Would R be zero? Can you give give a simple graphic solution?

G. H. C., St. Paul, Minn.

ANS.—The rise R cannot be zero. If the joints of the tile are truly or very nearly radial, as should be the case, the radius of the arch may be determined from the drawing by producing the lines of the joints



to an intersection. Then, by striking an arc of this radius, its rise for the given span can be easily found. If the joints are not truly radial, an arch-line may be constructed by drawing chords perpendicular to the joints and intersecting at the middle of the arch-tiles' as in the figure. By substituting in the formula the value of R thus determined, a reasonably approximate value of the thrust should be obtained, provided the constructed arch-line lies sufficiently within the limits of the arch-tiles to give enough material to resist the thrust, considering the arch-line to be at the center of the material in question.

***

(127) (*a*) Supposing I wish to cut a bastard thread, say 8 threads to the inch, and having the sides of the thread cut to an angle of 7°, what width would I have to make the point of the tool in order to cut the proper depth and have the top and bottom of the thread exactly the same? (*b*) Suppose I have a piece of stock 5¼ inches long which I wish to turn to a taper of ¾ inch to the foot, how far over would I want to set the dead center of my lathe?

F. H. F., Springfield, Vt.

ANS.—(*a*) Denoting the pitch of the thread by p, its depth by d, and the number of degrees of the angle of the thread by n, the width w of the tool may be figured from the formula $w = \frac{1}{2}p - (.0174533\,n + .0000018\,n^3)d$. In your example $p = \frac{1}{8}''$, and $n = 7$, and if you make $d = \frac{1}{2}p = \frac{1}{16}''$, you get $w = \frac{1}{16}'' - (.0174533 \times 7 + .0000018 \times 7^3)\frac{1}{16}'' = .0548''$. (*b*) See answer to question 332, in HOME STUDY MAGAZINE for September, 1897.

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(128) Is there any simple rule for finding any power of any number, such as the 49th power of 9? If so, please give the rule. W. T. B., Wayne, Pa.

ANS.—The only accurate way is to multiply out. By using logarithms, however, it may be obtained approximately in a very much shorter time. Thus, the logarithm of 9 is .95424. This figure multiplied by 49 is the logarithm of the 49th power of 9; $.95424 \times 49 = 46.75776$. Then the number of which this is the logarithm is found from the table to be 57248 followed by forty-five 0's; and if you write this number out you will have, approximately, the 49th power of 9.

***

(129) Kindly explain the action by which the so-called "student lamp" controls its oil supply.

J. C. T., Philadelphia, Pa.

ANS.—To clearly understand the principles involved in the student lamp, let us refer to the accompanying drawing. A removable oil-tank a, which is perfectly air-tight on top, is provided with a valve b at the bottom. This valve opens inwards and closes with its own weight. When the oil-tank is placed in position inside the shell c, the valve is raised from its

seat by the valve-stem resting on the bottom of the outer shell as shown. This allows oil to flow from *a* into the outer shell, from which it flows through a connecting-tube *d* into an annular oil-reservoir *e*, the top of which is open to the atmosphere. A round

wick *f* hangs in the oil in the reservoir *e* and conveys the oil up to the flame by capillary attraction. Now, to obtain a steady supply of oil to, and maintain a constant depth of oil in, the reservoir *e*, and thus secure a uniform supply of oil to the flame, is the object of the peculiar construction common to all "student lamps." It is accomplished in this way: the oil flows from *a* into *e* only when the oil in *e* is low enough to allow air to flow into *a* through the valve *b*. In other words, when the oil in *e* is higher than the bottom of *a*, air cannot get into *a*, because the opening at *b* is sealed, and, consequently, the oil cannot then escape from *a*. As soon, however, as the oil-level in *e* is low enough for air to reach the valve mouth, some air will rise into *a* and a corresponding amount of oil will fall into *e* and seal the mouth again. The gurgling noise so often heard in student lamps is due to the air rising up through the oil.

***

(130) (*a*) Are not the epicycloidal and hypocycloidal curves used for cast-iron spur gear-teeth? (*b*) What kind of teeth are used for bevel-teeth? (*c*) What kind of teeth are used for the rack and pinion?
W. F., Oakland, Cal.

ANS.—(*a*) Yes, some firms still use them; we recommend the involute tooth, however. There is really no excuse for the perpetuation of the cycloidal tooth; those who first made it knew no better, and it is a bad habit which should be eradicated. (*b* and *c*) Involute teeth should always be used. Of course, the cycloidal *may* be used, but they have no advantages, whereas they possess one great disadvantage—they are not adjustable, and unless the pitch lines roll upon one another exactly, that is to say, unless the distance from center to center of gears is exactly and theoretically correct, the uniformity of motion between the two gears is destroyed.

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(131) How are gasoline and similar oils tested?
A. C. S., Normal, Ill.

ANS.—Much depends upon the purpose for which the oil is to be used. Gasoline, benzine, and the lighter petroleum products are usually rated by their specific gravity according to Beamé's scale. This is found by a floating instrument called a hydrometer, the distance the instrument sinks into the liquid determining the specific gravity by a scale marked on the instrument. Kerosene or lamp oil is rated by its flashing point. Thus, 150-test oil will give off an inflammable vapor at 150° F. Lubricating oils are tested for flashing-point, durability under pressure on a journal, lubricating power and viscosity. The latter is tested by allowing the oil to flow through a small hole.

***

(132) Can you give me the formula for the so-called "quick process" of blue-print paper?
W. H. W., Toledo, Ohio.

ANS.—The rapid printing qualities of all blue-print paper depend almost entirely upon the age of the paper. The freshly prepared paper prints much more readily than that which is old, and it is therefore better to make a small quantity of the paper at a time and use it within three days after preparation. The following formula will be found well suited to these circumstances:

Ammonio-citrate of iron	16 grs.
Water	½ oz.
Red prussiate of potash	12 grs.
Water	2 dr.

After dissolving, mix and spread upon paper with a brush or sponge, and dry without heat in an ordinarily warm room.

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(133) Can you give me a receipt for browning the twist barrels of a shotgun, which have been worn bright?
W. D., Detroit, Michigan.

ANS.—You will find the receipt in answer to question 219, July, 1897, number of HOME STUDY MAGAZINE.

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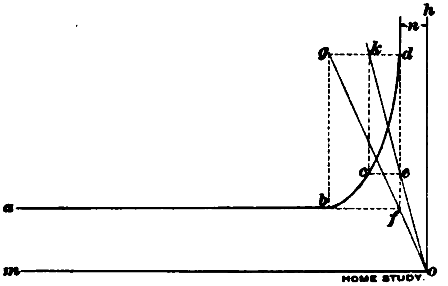
(134) Having an indicator-card, how is the clearance-space calculated if the exhaust line is the same as the atmospheric line? J. R. L., Cincinnati, Ohio.

ANS.—Referring to the accompanying figure, *ab* is the exhaust line, and *bd* is the compression curve. Through *b*, the beginning of compression, draw the vertical *bg*, and, through the end of the compression curve, draw the horizontal *gd*. Take any point on the curve, as *c*, and draw *ck* and *ce* vertical and

horizontal, respectively. Draw also the vacuum line om. Now, through k, where the line ck cuts gd, and through e, where ce cuts df, draw ke cutting om at o.



Also, through g and f draw gf, which should also cut om at o. Through o draw the vertical oh; it is the clearance line. From the distance n the clearance space can be calculated. This method is not very accurate in any case, and is only approximately true even when the card is good and shows a clear compression curve.

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(135) (*a*) I wish to establish a small plant to generate, from gasoline, sufficient gas to do soft-soldering on light jobs of brazing. I constructed a carburetter by half filling a tin can with gasoline and pumping air through a tube which reached below the surface; the gas I obtained gave a fine light, but I find that, apparently, I get just as good a light by forcing the air *over* the surface of the gasoline instead of under. Is this so? Do I infringe anybody's patents by using either method. (*b*) In regard to the air pump, it strikes me that a considerable volume of air at a constant and low pressure is required. I do not want to use the flame for more than ten minutes at a time, on an average, and I cannot decide on a suitable kind of pump. If I used a falling weight to drive a small fan or pump, would I infringe any patent? I I shall be glad of any information you can give me; I may add that I have electric power and could construct a small motor suitable for operating a pump.
W. H. C., Bar Mills, Me.

Ans.—(*a*) and (*b*) You should arrange your carburetter so that the air will come directly in contact with as much gasoline as possible. You cannot make the gas too rich for blowpipe work, because you will have an air blast besides, so that you can mix the gas and air in proper proportions at the blowpipe. If you allow the air to pass over the gasoline only you will find that the charge will become less volatile as it is evaporated, until finally the air will pass over the liquid without becoming properly carburetted. Carburetters, as you call them, are usually well filled inside with some absorbent material, such as cotton wadding or porous screens, so that the gasoline, by capillary attraction, will rise and thoroughly wet the screens. The air is blown through this porous material and becomes thoroughly saturated with gasoline vapors. We cannot say positively, but we believe that you will not infringe on any patent by blowing through or over gasoline as you have been doing. Neither do we believe that any patent covers the principle of obtaining power to drive a pump by means of a falling weight. We think you will do well to fit up an electric pump, and use a 60-gallon kitchen boiler for an air-storage tank. Use a diaphragm-controller to operate the motor-switch when the pump is wanted to work or to stop. The air pressure will thus control the motor.

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(136) (*a*) What is the steam-drum of a boiler? Where is it situated, and what is it used for? (*b*) What is the mud-drum of a boiler? Explain its use and situation. (*c*) What is a good paint or preparation to put on an uncovered boiler? The boiler is new and the paint now on it flakes off and looks badly. M. B. S., Beckel, Mass.

Ans.—(*a*) The steam-drum on a stationary boiler fulfils the same duty as the dome on a locomotive, namely, to supply dry steam to the engines. It allows the source of supply to the engines—the throttle in the locomotive and the steam nozzle on the stationary engine—to be removed to a greater distance above the water-level. The drum is cylindrical, with humped heads, and is placed above the top of the boiler, the connection being made through two short cylindrical legs. (*b*) The mud-drum is placed underneath the boiler. It forms a receptacle in which the sediment can collect, whence it is removed at will. The frequency of cleaning out depends, of course, on the purity of the water that is fed to the boiler. (*c*) Paint your boiler with a mixture of asphalt and varnish. This will stand the heat all right. The varnish gives the boiler a good appearance.

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(137) Can you give me a receipt for aluminum solder? C. W. R., Baltimore, Ohio.

Ans.—

Take	8	parts	of	aluminum	with	92	parts	of zinc,	or
	12	"	"	"	"	88	"	" "	or
	15	"	"	"	"	85	"	" "	or
	20	"	"	"	"	80	"	" "	

Melt the aluminum; add the zinc slowly; finally, add some fat and stir with an iron rod, and cast. For a flux use 3 pints of copaiba balsam, 1 pint of Venice turpentine, with a few drops of lemon juice added. Dip the point of the soldering iron into the flux.

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(138) Is there such a thing as granulated tin tartar? red oxide of nickel? tartrate of cobalt? Where can they be obtained? H. S. S., Reynolds, Pa.

Ans.—We do not know what is meant by granulated tin tartar; red oxide of nickel is also unknown to us. Nickel sesquioxide (Ni_2O_3) is grayish black, while nickel monoxide (NiO) has a green color. There are such substances as cobalt tartrate and tin tartrate. These, however, cannot be obtained here, but may be imported through Eimer & Amend, New York City.

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(139) (*a*) What size of pipe will it require to steam-heat a greenhouse, the dimensions of which are 12′ x 12′ x 8′ high, slant of roof 45°? I desire a day temperature of 70° F., and a night temperature of 50° F. (*b*) The boiler is 5 feet from the greenhouse; could I not use a 4′ x 2′ high-pressure boiler, with a ½-inch supply-pipe to greenhouse and connect drain-pipe to the boiler? (*c*) Would it be necessary to put a reducing-valve on the supply-pipe? There is also a small engine attached to the boiler. (*d*) If my drain-pipe rises 4 or 5 feet and then drops again the same distance to the blow-off pipe to enter the boiler, would it work right? Make what suggestion you can to help me? J. T. M., Rox, Mass.

Ans.—We assume that your greenhouse has a glass roof, glass sides 2 feet high, and one glass end, which means about 320 square feet of glass in all. (*a*) Half-inch pipe is too small. One-inch pipe is large enough, but if the water line in the boiler is not more than 2 feet 6 inches lower than the heating-coils we would advise you to use 1¼-inch pipe all through. (*b*) You cannot determine the capacity of a boiler by its outside dimensions. Your boiler should have about 12 square feet of heating and about .4 square feet of grate surface at least for the greenhouse work. Connect the return-pipe to the boiler at a point below the water-level; near the bottom is the best place. (*c*) If there is an engine attached to the boiler, of course, you must run high-pressure steam, but it is not necessary to place a pressure-reducing valve on

the supply to greenhouse if you use pipe radiation. Your best plan is to valve the greenhouse radiation in sections so that any or all sections may be turned on to suit the weather. (*d*) Do not raise the return-pipe. Your best plan is to cut a road for it to grade down to the boiler. By adhering to the above suggestions you can easily heat your building with high-pressure steam on the gravity return system, which is the best in all cases.

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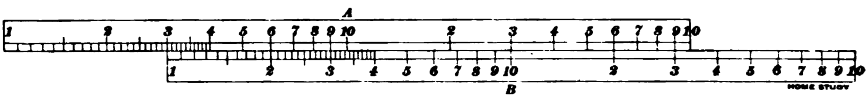
(140) (*a*) Please explain the principle on which the Amsler planimeter works. I cannot see why the wheel movement is proportional to the *area* of the figure traced. (*b*) Please explain the principle on which the "Manheim" slide-rule or the "Fuller" spiral slide-rule is based. (*c*) Can you tell me of some good treatise on these subjects?

H. P. W., Seattle, Wash.

ANS.—(*a*) This is too large a subject to deal with in these columns. We have prepared an exhaustive article on Amsler's polar planimeter, which will probably appear, in two parts, in early numbers of the Magazine. (*b*) The principle of the slide-rule is illustrated in the accompanying figure. A is a rule divided into 2 equal parts; each half is divided into 10 parts, obtained by laying off, from the left-hand end of each of the two main divisions, the distances 1-2 (or 10-2), 1-3 (or 10-3), 1-4 (or 10-4), etc., proportional to the logarithms of the numbers between 1 and 10; so that 1-2 (or 10-2) may be taken to represent log 2, or .301; likewise, distance 1-3 (or 10-3) = log 3 = .477, distance 1-4 = log 4 = .602, etc. Suppose, now, that another rule is graduated just like the preceding one, shown at B, and is placed so that it can slide along the rule A. Let us see what the relative positions of the divisions of the rules are, when their 1-marks do not coincide. Suppose the 1-mark of B to be under the 3-mark of A, as shown in the figure. Then the distance 1-3 on A is equal to the logarithm of 3, and, if to that distance we add, say, the distance 1-2 on B, which is the logarithm of 2, we shall have the logarithm of 3×2, since the logarithm of a product equals sum of logarithms of factors; therefore, the division of A directly above the division 2 of B, must be at a distance from 1 equal to the logarithm of 2×3, or 6; and, as on A are marked the numbers corresponding to the various logarithms measured from 1, the number 6 is found at the end of the distance representing its logarithm, that is, directly over the division 2 of B. Likewise, 1-3 on A = log 3, 1-3 on B = log 3; sum of the two equals log (3×3) = log 9, the number 9 being found on A directly over the 3-mark of B. In the same manner the product of other two numbers might be found; but, in order to have a greater range of numbers, it is necessary to divide each half of the rules into a greater number of parts, as 100 or 1,000, making the distances from the first mark proportional to the mantissas of the logarithms of the numbers between 10 and 100, or between 100 and 1,000, as the case may be. Four of the main spaces of A and B, in the figure, are shown subdivided in such a manner that the distances from 1 to the successive divisions between 1 and 2 represent the mantissas of the logarithms of 11, 12, 13, etc.; from 1 to the divisions between 2 and 3, the logarithms of 21, 22, 23, etc. Let it be required to find the product of 23 by 32. Placing the 1-mark of the slide B on the 23-mark (3 divisions to the right of 2) of the rule A is equivalent to taking the logarithm of 23 (neglecting the characteristic), off the rule A; if now we take the division marked 32 (2 divisions to the right of 3), on the slide B, this will be equivalent to taking the logarithm of 32 off B, counting from 1; therefore, this distance, added to the preceding distance on A, gives log 32 + log 23 = log (23×32), and the corresponding number on A, indicated by the division mark over the 32-mark of B, must be the product. In this case, the 32-mark of B will be found to lie between the 73-mark and the 74-mark of A, a little nearer to the latter than to the former, so that it is easy to estimate that the product is *about* 736. This is the true product, but, in general, the third figure, as estimated, will not be exact. If the rules are divided into 1,000, 10,000, etc. parts, any degree of approximation may be obtained. The rules may be made circular, or in any other convenient form, and constructed for the extraction of roots, the solution of trigonometric formulas, etc.; but the underlying principle is the same, namely, the theory of logarithms. (*c*) Hoare's "Slide-Rule and How to Use It" (D. Van Nostrand, New York, $1.00), Cox's "Slide-Rule" (Keuffel & Esser, New York, $0.50).



Good sections on the planimeter and its uses are found in advanced books on surveying, as Johnson's "Theory and Practice of Surveying" (J. Wiley, New York, $4.00), and Raymond's "Plane Surveying" (American Book Co., New York, $3.00). The latter book contains a good section on the slide-rule, by Prof. C. W. Crockett, of Troy.

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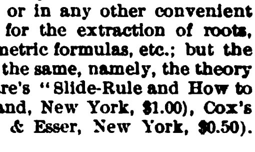
(141) Will you kindly solve the following problem? A ladder placed in the street reaches the height of 40 feet when placed against one side of the street; and when turned over to the other side reaches a height of 30 feet. What is the width of the street?

F. C. C., El Reno, O. T.

ANS.—If l denote the length of the ladder, the width of the street = $\sqrt{l^2 - 40^2} + \sqrt{l^2 - 30^2}$. When the length of the ladder is known, this formula gives the width of the street; for example, if the ladder is 50 feet long, the width of the street = $\sqrt{50^2 - 40^2} + \sqrt{50^2 - 30^2} = 30 + 40 = 70$ feet.



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(142) (*a*) Given the slope of the bottom of a stream, the average depth and height of dam (see sketch enclosed), what is the general formula for determining how the water will be backed, and what will be the depth d_2 at any distance x from the dam? (*b*) Rankine's formula for this in "Civil Engineering," page 690, is

$$x = \frac{d_1 - d_2}{i} + \left(\frac{1}{i} - 264\right) \times (v_1 - v_2)\, d_0,$$

v_1 and v_2 being functions of $r_1 = \frac{d_1}{d_0}$ and $r_2 = \frac{d_2}{d_0}$.

Now d_1 is the depth of water just back of the weir, and d_2 is the depth of water back of weir a distance x, d_0 being original depth of steam; consequently r_2 is always smaller than r_1. $v = \frac{1}{2r^2} + \frac{1}{5r^5} + \frac{1}{8r^8}$ (approximately): v_2 must always be greater than v_1, and the second term of the equation is, therefore, negative, a result which is contrary to fact; and in the paragraph below the mathematical discussion in Rankine it is expressly so stated, since the only condition which can make the second term negative is

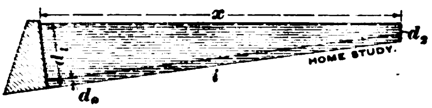
where $\frac{1}{i}$ is less than 264 (i being rate of fall), that is, when i is steeper than 1 in 264. (*c*) Is there any simpler or more accurate formula? (*d*) Does it make any difference whether the bottom of the stream is uniform as to the general contour of water impounded?

W. C. McG., Chambersburg, Pa.

ANS.—(*a*) In Church's Hydraulics (Mechanics of Engineering, page 772) is given a formula for the extent of backwater which, with symbols changed to correspond with those employed by Rankine, may be written:

$$x = \frac{1}{i}\left[d_1 - d_2 + \left(d_0 - \frac{s^2}{g}\right)\left(v_2 - v_1\right)\right],$$

in which s is the velocity of original uniform flow. Accompanying the formula are tabulated values of v



the same as given by Rankine, to whom reference is made. In Merriman's Hydraulics is also given a formula for backwater which, with symbols changed to correspond with those used by Rankine, is as follows:

$$x = \frac{d_1 - d_2}{i} + d_0\left(\frac{1}{i} - \frac{c^2}{g}\right)(v_2 - v_1).$$

In this formula, c is the velocity coefficient whose value is given by Kutter's formula, and v is written for the function $v\,\frac{d}{d_0}$, for which the values are given by a table taken from Bresse's "La Mecanique Appliquee," which table, though more extended than Rankine's, gives values agreeing closely with those given in the latter table. This formula, as given by Merriman, is the same as that given by Church, though written in slightly different form. For $s^2 = c^2 d_0 i$, and by substituting this value for s^2 in the latter, it reduces to the former. Rankine's formula differs from these slightly in the second term. (*b*) In the formula given by Merriman and Church, the last term is written $(v_2 - v_1)$ instead of $(v_1 - v_2)$ as in Rankine's formula. The latter is probably an error. (*c*) We know of no formula for the purpose simpler or more accurate than those given. (*d*) If the slope, depth, or width changes materially, the formula should not be applied with x taken for the entire distance, but the stream should be divided into reaches of such length that for each reach these quantities may be considered constant. The formula can then be applied to the first reach and its upper depth d_2 determined. Then calling this depth d_1, the formula can be applied to the second reach, etc. In any case, the depth d_0 should be the hydraulic depth, that is, the hydraulic radius, computed from actual measurements of the area and wetted perimeter of the cross-section of the original uniform flow.

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(143) I wish to be informed upon some points on wagon construction. (*a*) Why is an axle "gathered," and how do you proceed to lay out a wooden axle in order to obtain the "gather"? (*b*) How is a wagon tracked? (*c*) Why is a wheel dished? (*d*) Is it true that a lumber wagon wheel in the boxes of which there is a great deal of chuck is very easy running; is this so, and why? (*e*) Do you know of a good paper devoted to wagon-making?

ANS.—(*a*, *b*, *c*) We are not informed upon these subjects. (*d*) A little side play, chuck, or shuck, as it is variously called, is very necessary, otherwise the wheels will bind sideways. (*e*) "The Blacksmith and Wheelwright," 27 Park Place, New York City.

(144) Enclosed you will find four indicator-diagrams taken from a 9″ x 12″ common slide-valve engine. Kindly explain them.

A. J. P., Hartford, Wis.

ANS.—AB is the *admission* line, BC the *expansion* line, CD the *back-pressure* line, and DEF the *compression* line. The "waves" at the beginning of the admission line are solely due to the momentum of

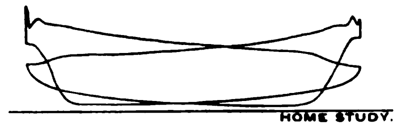

FIG. 1.

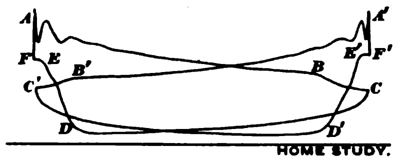

FIG. 2.

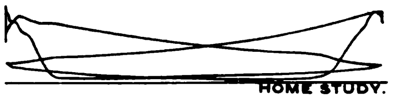

FIG. 3.

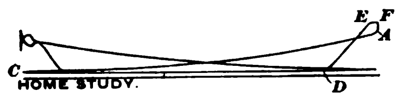

FIG. 4.

the moving parts of the indicator. The sudden turn of the compression line at E is a peculiarity often met with, but not always easy to account for; it may be due to the piston having only one packing-ring, which then runs into the counterbore of the cylinder, thereby causing leakage past the piston. For the peculiarity of the termination of the left-hand compression curve in diagrams 3 and 4 we have no explanation to offer. The diagrams show that the exhaust occurs too late, causing a high back-pressure line, and that the compression occurs too early. This can be remedied by reducing the inside laps of the valve. The diagrams may possibly be further improved by giving the eccentric a trifle more advance.

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(145) Please work out the following example by use of simple arithmetic, as I do not understand much about algebra: A steamer is to make a voyage of 3,000 miles; the engine is an inverted compound, surface-condensing; the cranks are set at 90 degrees. The high pressure cylinder is 42″ x 60″; low pressure is 84″ x 60″, and each cuts off at ½ stroke. The boiler gauge-pressure is 85 pounds. It is required to know how much coal to take on board. If you need other information you may assume whatever will make it possible to solve the question.

J. W. J., San Francisco, Cal.

ANS.—We will assume the speed of the steamer to be 10 miles per hour, then the time required to make the voyage of 3,000 miles is 3,000 ÷ 10 = 300 hours. The engine will develop about 50 horsepower per revolution; hence, if we assume that it runs at a speed of 70 revolutions per minute it will develop a total of about 3,500 horsepower. With the engine and boilers in fairly good condition and well managed the coal consumption should not exceed 2½ pounds per

horsepower per hour. Under these conditions the coal required for the voyage of 3,000 miles is $300 \times 3{,}500 \times 2\frac{1}{2} = 2{,}625{,}000$ pounds, or $2{,}625{,}000 \div 2{,}240 = 1{,}172$ long tons, nearly.

* * *

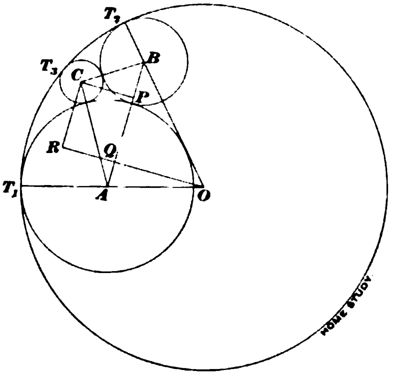
(146) Please explain how to find the diameter of the circumscribed tangent circle, in enclosed sketch, the diameters of the inscribed circles being 2″, 1″, and ½″, respectively. F. G. E., Union Bridge, Md.

ANS.—The sides of the triangle ABC are $BC = \frac{3}{4}''$, $CA = \frac{5}{4}''$, and $AB = \frac{3}{2}''$. Hence, we find $CP = \frac{\sqrt{14}}{6}$, and $AP = \frac{13}{12}$. Denote AQ by x and QO by y.

The radius of the circumscribed circle =

$$OT_1 = OA + AT_1 = OT_2 = OB + BT_2.$$

Therefore, $$OA + 1 = OB + \tfrac{1}{2}. \quad (1)$$



Or, $$\sqrt{AQ^2 + QO^2} + 1 = \sqrt{QB^2 + QO^2} + \tfrac{1}{2},$$
and $$QB = AB - AQ = \tfrac{3}{2} - x.$$

Therefore, $$\sqrt{x^2 + y^2} + 1 = \sqrt{(\tfrac{3}{2} - x)^2 + y^2} + \tfrac{1}{2}. \quad (2)$$

Again, $$OT_1 = OA + AT_1 = OT_3 = OC + CT_3.$$

Therefore, $$OA + 1 = OC + \tfrac{1}{4}. \quad (3)$$

Also, $$OC = \sqrt{RO^2 + RC^2} =$$
$$\sqrt{(CP + QO)^2 + (AP - AQ)^2} =$$
$$\sqrt{\left(\frac{\sqrt{14}}{6} + y\right)^2 + \left(\frac{13}{12} - x\right)^2}$$

Therefore, from (3), $\sqrt{x^2 + y^2} + 1 =$

$$\sqrt{\left(\frac{\sqrt{14}}{6} + y\right)^2 + \left(\frac{13}{12} - x\right)^2} + \tfrac{1}{4}. \quad (4)$$

From (2) and (4), by transposing and squaring, we get

$$\sqrt{x^2 + y^2} = 2 - 3x. \quad (5)$$

$$\tfrac{3}{2}\sqrt{x^2 + y^2} = -\frac{13}{6}x + \frac{\sqrt{14}}{3}y + 1. \quad (6)$$

Therefore, $$\tfrac{3}{2}(2 - 3x) = -\frac{13}{6}x + \frac{\sqrt{14}}{3}y + 1.$$

Or, $$\sqrt{14}\,y = 6 - 7x.$$

Substituting this value for y in (5) we get

$$x = .3103183;$$

and hence, $$y = 1.023015.$$

$$OA = \sqrt{x^2 + y^2} = 1.0690253.$$

Diameter of circumscribing circle

$$2 \times OT_1 = 2(OA + AT_1) = 2(1.0690253 + 1) = 4.1380506.$$

* * *

(147) (*a*) I have an air reservoir with a capacity of 5,000 cubic inches which I charge to 70 lb. pressure per square inch. To this I connect a smaller reservoir of 400 cubic inches capacity. On the larger one I have a gauge and I let 5 lb. pass from the large to the small vessel, which latter was empty. What pressure per square inch will small reservoir show and how is it calculated? (*b*) How can I lay off any desired distance on the circumference of a circle?

J. P. B., Somerset, Ky.

ANS.—(*a*) Your large vessel contains 5,000 cubic inches of air at an absolute pressure of $70 + 14.7 = 84.7$ pounds per square inch. Conceive this vessel to be elongated so as to let the air expand sufficiently to cause the pressure to drop to 79.7 absolute, i. e., 5 pounds, and call the new volume V. Then, assuming the temperature to remain constant,

$$79.7\,V = 5{,}000 \times 84.7;$$

whence, $$V = \frac{5{,}000 \times 84.7}{79.7}.$$

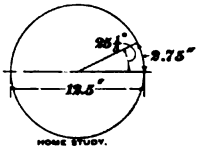
Now, $(V - 5{,}000)$ cubic inches at 79.7 pounds, absolute, pass into the small vessel, producing a pressure p and filling a volume of 400 cubic inches.

Therefore, $400\,p = (V - 5{,}000) \times 79.7;$

whence, $$p = \frac{\left(\frac{5{,}000 \times 84.7}{79.7} - 5{,}000\right) \times 79.7}{400} =$$

$$\frac{5{,}000 \times (84.7 - 79.7)}{400} = \frac{25{,}000}{400} = 62\tfrac{1}{2} \text{ lb., absolute.}$$

The gauge pressure will be 14.7 pounds less than this, or 47.8 pounds. We have taken the word "empty" as implying the existence of a vacuum in the small vessel and have assumed the temperature to equalize and become the same in both vessels. (*b*) To obtain what you require, lay off at the center of the given circle an angle containing $\left(\frac{L}{S} \times 360\right)$ degrees, where $L =$ the length to be laid off and $S =$ the circumference of the circle. Thus, suppose it is required to lay off a distance of $2\frac{3}{4}$ inches on the circumference of a circle $12\frac{1}{2}$ inches in diameter. The circumference of this circle $= 12.5 \times 3.1416 = 39.27$ inches: therefore, the central angle equals



$$\frac{2.75}{39.27} \times 360 = 25\tfrac{1}{5}°, \text{ say.}$$

* * *

(148) (*a*) How can I make an electric battery such as are used by sick people? Is not a dry battery the best kind for the purpose? (*b*) Where can they be procured and at about what price?

J. R. B., Fredericksburg, Va.

ANS.—(*a*) A medical battery outfit generally includes a battery, an induction-coil, handles, footplates, and proper cords. The battery may be a dry or an acid cell. The manner of constructing a dry cell is given in answer to question 295 in the August, 1897, number of HOME STUDY MAGAZINE. (*b*) J. Elliot Shaw, 632 Arch Street, Philadelphia, Pa. Outfit costs about $7.00; dry cell can be obtained for 25 or 30 cents.

* * *

(149) (*a*) Kindly explain the working of Corliss valves and dashpots. (*b*) Give me a rule for determining the number of square feet of cooling surface that a condenser should have for given size of engine. (*c*) How is a pantograph designed for any particular engine? (*d*) I am running a 200-horsepower engine and have considerable trouble with the pillow-block next to the crank. The shaft pounds very badly; it seemed loose, but when I took up the brasses the bearing got hot. Can you tell me what the cause is likely to be? F. M. V., Palatka, Florida.

ANS.—(*a*) This subject will be dealt with in an early number of this magazine. (*b*) The size of surface-condensers is generally calculated upon a basis of so many square feet of cooling surface to one indicated horsepower. This amount, again, depends

on the temperature of the circulating water and also on the terminal pressure that is desired. In current practice the following amounts are generally allowed, the temperature of the water being taken at 60° F.:

Terminal Pressure (Absolute).	Cooling Surface in Square Feet Per Indicated Horsepower.
6 pounds.	1.3
10 "	1.43
15 "	1.57
30 "	2.2

(*c*) This will be made the subject of an article shortly. (*d*) Perhaps the pound was not in the main bearing at all, but in the crank-pin. You do not say whether the pound ceased after you had let the main bearing together. You can locate a knock in the main rod by holding your hand on it and following it around for a few revolutions—if it does not run more than, say, 100 revolutions a minute. You should exercise care in any case while you are doing this. If your engine is reversible, get your helper to start her very slowly and then reverse her quickly with steam on. You can then see, by close inspection, where the play is. Practice is required in order to locate the various pounds in an engine. In your case it may be that you located the trouble right enough, but took too much off the top brass. You should have taken a "diagram" of the bearing before stripping the brass. That is the safest way in such cases. You do not say whether your main bearing "lets together" vertically or diagonally. If the former, perhaps the journal was knocking in the brass fore-and-aft or the brass may have been loose in the frame. In such cases you might take up the play at top and bottom and still leave some in a fore-and-aft direction. To see if the latter is the case, put her on the center and turn steam on and watch the bearing and the end of the crank-shaft.

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(150) The enclosed sketch represents a grillage girder supporting two unequally loaded columns. It is evident that the girder must be figured by turning it upside down and using the column loads as the reactions. Will you kindly show me what kind of loading to use and how I can find it?

B. and C. D., Steelton, Pa.

ANS.—If, as suggested, we consider the girder turned upside down, and loaded with twelve loads

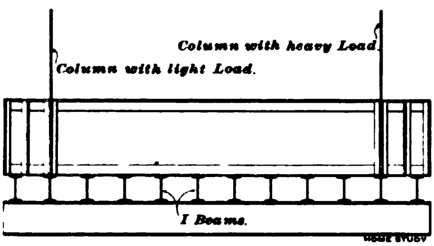


FIG. 1.

situated at equal distances apart, corresponding to the positions of the twelve transverse I beams, and, considering the known column loads as reactions, attempt to determine statically the comparative magnitudes of the I-beam loads that will give these reactions, we will find the problem indeterminate. The reactions may be given by any one of a large number of different systems of loading. It will, therefore, be necessary to make some reasonable assumption limiting the conditions. If the reactions (i.e., column loads) were equal, it would usually be assumed that the I-beam loads were of uniform magnitude, that is, that an equal portion of the total superimposed load was transmitted to the foundation by each transverse I beam. Although the actual conditions might differ somewhat from this assumption, the assumption would, in most cases, be reasonable and permissible. When the column loads, or reactions, are unequal, as in the present case, it will probably approximate the conditions sufficiently if we assume the end I-beam load adjacent to the light column to be the lightest, and the end I-beam load adjacent to the heavy column to be the heaviest, and the intermediate I-beam loads to vary uniformly from the lightest to the heaviest in such a manner that the center of gravity of all the I-beam loads will coincide with the center of gravity of the column loads. In Fig. 2, the girder is represented as

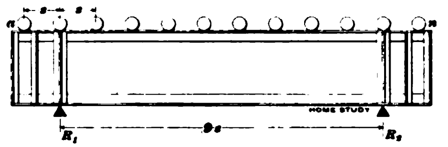


FIG. 2.

supported upon the columns, or reactions, and carrying the twelve loads, whose positions are fixed by the uniform distance s. R_1 is assumed to be the lighter, and R_2 the heavier reaction; consequently, a is the lightest and n the heaviest load. Let x be the weight of a and let y be the increment for each load, passing to the right. That is, y is the amount by which the weight of each load exceeds the weight of the adjacent load at the left. By taking moments about R_2, we have

$$9sR_1 - 10sx - 9s(x+y) - 8s(x+2y) - 7s(x+3y) - 6s(x+4y) - 5s(x+5y) - 4s(x+6y) - 3s(x+7y) - 2s(x+8y) - s(x+9y) + s(x+11y) = 0,$$

and
$$R_1 = 6x + \frac{154y}{9}. \quad (1)$$

Likewise, by taking moments about R_1, we have

$$-9sR_2 - sx + s(x+2y) + 2s(x+3y) + 3s(x+4y) + 4s(x+5y) + 5s(x+6y) + 6s(x+7y) + 7s(x+8y) + 8s(x+9y) + 9s(x+10y) + 10s(x+11y) = 0,$$

and
$$R_2 = 6x + \frac{440y}{9}. \quad (2)$$

Subtracting (1) from (2), we get

$$y = \frac{9(R_2 - R_1)}{286}. \quad (3)$$

By substituting in (1) the value of y as given by (3), we have

$$R_1 = 6x + \frac{154(R_2 - R_1)}{286},$$

or
$$x = \tfrac{1}{6}[R_1 - \tfrac{7}{13}(R_2 - R_1)]. \quad (4)$$

For example, let it be assumed that R_1 and R_2 are equal to 97,200 and 183,000 pounds, respectively. Then, from (4),

$$x = \tfrac{1}{6}[97{,}200 - \tfrac{7}{13}(183{,}000 - 97{,}200)] = 8{,}500 \text{ pounds};$$

and, from (3),

$$y = \frac{9(183{,}000 - 97{,}200)}{286} = 2{,}700 \text{ pounds.}$$

Having determined the weight of the lightest load and the increment, the weight of every other load can be found very easily.

***

(151) (*a*) Where can I get the Machine Shop Arithmetic noticed in HOME STUDY MAGAZINE for

June, 1896? (*b*) Do you know of any treatise on metal-polishing by means of emery-wheels and belts?

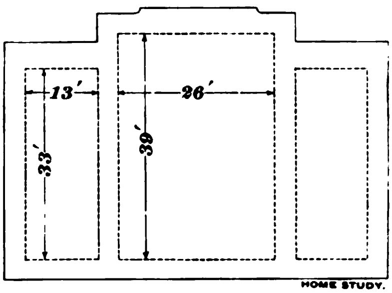
W. A. P., Hattsburg, N. Y.

ANS.—(*a*) We will send you a copy on receipt of 50 cents. (*b*) Baird & Co., of Philadelphia, publish a book by Laughlin on the electro-deposition of metals, which contains a chapter on grinding and polishing wheels; price, $4. Ask them to send you a catalogue; they may have other and cheaper books dealing with the same subject.

***

(152) Kindly figure out the seating capacity of hall in enclosed sketch. E. A. L., Jersey City, N. J.

ANS.—The proper allowance for seating individuals in a hall or theatre is 2′ 0″ in width × 2′ 6″ in depth. This, according to your diagram, would permit in



each of the side sections thirteen rows with six persons in each row, while, the center section would contain fifteen rows, with thirteen in each row, or a total seating capacity for the room of three hundred and fifty-one.

***

(153) Is there anything known about the evolution of the bird from the snake?

W. B. C., Niagara Falls, N. Y.

ANS.—Nothing that we are aware of.

***

(154) I wish to make an induction-coil that will give a 2-inch spark. I have several pounds of No. 26 wire which I would like to use in the secondary coil. (*a*) What would be the dimensions of the iron-wire magnet and what size wire would be used in it? (*b*) Would it do to enclose the magnet in a hard-rubber spool and then wind the primary coil on the spool? (*c*) How many layers and what size of wire should be used for the primary circuit? (*d*) What is the total number of pounds required for the secondary coil? (*e*) What size sheets and how many should be used in the condenser? P. B., Knoxville, Iowa.

ANS.—(*a*) In the answer to question 395 in the October, 1897, number of HOME STUDY MAGAZINE you will find a description of an induction-coil, with general dimensions, from which you can find the size of core. (*b*) You can use such a method; but the tube must be long enough to project over the primary winding at each end. The method described in the above number of this magazine is, however, a very good one. In any case, leave plenty of room between the primary and secondary, and use paraffin in addition to the hard-rubber spool. (*c*) Two layers, No. 16 double cotton-covered wire. (*d*) You will require, probably, about ten pounds of wire, as it is so coarse. (*e*) See answer to question 395 already referred to.

***

(155) How can I calculate the length of time that a fan making 200 revolutions per minute will take to evaporate 75 per cent. of water out of an article, the temperature being 75° F.

C. R. M., Wheeling, W. Va.

ANS.—You have not given us sufficient information on which to base an answer. In any case, however, problems of this kind can be solved by experiment only.

***

(156) How is equation (3) derived from equation (1), also (4) from (1) in question 277 in the August number of HOME STUDY MAGAZINE?

P. K., New York City.

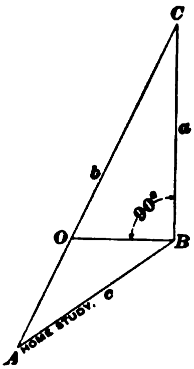
ANS.—In any triangle

$$\frac{\sin A + \sin B}{\sin C} = \frac{a+b}{c}. \qquad (1)$$

Or,

$$\frac{a+b}{c} = \frac{\sin A + \sin B}{\sin(A+B)} = \frac{2\sin\frac{A+B}{2}\cos\frac{A-B}{2}}{2\sin\frac{A+B}{2}\cos\frac{A+B}{2}} =$$

$$\frac{\cos\frac{A-B}{2}}{\cos\frac{A+B}{2}} = \frac{\cos\frac{A}{2}\cos\frac{B}{2} + \sin\frac{A}{2}\sin\frac{B}{2}}{\cos\frac{A}{2}\cos\frac{B}{2} - \sin\frac{A}{2}\sin\frac{B}{2}} = \frac{1+\tan\frac{A}{2}\tan\frac{B}{2}}{1-\tan\frac{A}{2}\tan\frac{B}{2}}.$$



Therefore,

$$\tan\frac{A}{2}\tan\frac{B}{2} = \frac{a+b-c}{a+b+c}.$$

Putting $a + b = 150$, and $c = 50$, we get

$$\tan\frac{A}{2}\tan\frac{B}{2} = \tfrac{1}{2}. \qquad (3)$$

Again,

$$\frac{a+b}{c} = \frac{\cos\frac{A-B}{2}}{\cos\frac{A+B}{2}} = \frac{2\cos\frac{A-B}{2}\cos\frac{A+B}{2}}{2\cos^2\frac{A+B}{2}}$$

$$= \frac{\cos A + \cos B}{1+\cos(A+B)}.$$

Therefore,

$$\cos A + \cos B = \left(\frac{a+b}{c}\right)[1+\cos(A+B)].$$

From (1), $\sin A + \sin B = \left(\frac{a+b}{c}\right)\sin(A+B)$.

Squaring and adding, and dividing by 2,

$$1 + \cos A\cos B + \sin A\sin B =$$
$$\left(\frac{a+b}{c}\right)^2[1+\cos A\cos B - \sin A\sin B].$$

Therefore,

$$\left[\left(\frac{a+b}{c}\right)^2 - 1\right]\cos A\cos B - \left[\left(\frac{a+b}{c}\right)^2 + 1\right]$$
$$\times \sin A\sin B + \left[\left(\frac{a+b}{c}\right)^2 - 1\right] = 0.$$

Putting $\frac{a+b}{c} = 3$, and dividing by 2, we get

$$4\cos A\cos B - 5\sin A\sin B + 4 = 0. \qquad (4)$$

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HORSEPOWER.

George A. Goodenough.

MISUSE OF THE TERM POWER—DISTINCTION BETWEEN WORK AND POWER—FORMULAS FOR THE HORSEPOWER OF THE STEAM ENGINE, FAN, AND PUMP.

THE term power is perhaps more frequently misused than any other in the province of mechanics. "Motive power" is used when "motive force" is meant; *power* and *power arm* are used in connection with the lever, the idea of power being confused with that of force. Again, power is frequently spoken of as being identical with work; thus, it is not uncommon to see the statement that power is the product of force by distance, and that 1 horsepower is equal to 33,000 pounds raised 1 foot. The misuse of these mechanical terms is, of course, frequently due to carelessness; but there is no doubt that the confusion of the terms results from a confusion of the ideas which they represent. Force, work, energy, and power are quantities that play an important part in mechanics; and it is very essential that the student of mechanics or engineering should have, from the outset, clear and precise notions regarding the true nature of each of these quantities, and of the relations existing between them.

Work is usually defined as the production of motion against a resistance. In order that work may be done, two things are necessary: a motion, and a force sufficient to produce the motion. If the force is not sufficient to overcome the resistance, no motion will ensue, and no work will be done. A man who is able to exert an upward pull of 300 pounds does work when he lifts a stone weighing 200 pounds; if he attempts to lift a stone weighing 325 pounds, the force he is able to exert is not sufficient to overcome the downward pull of gravity, and the stone remains at rest. Though the effort to lift the heavy stone may fatigue the man more than the lifting of the light one, there is no work done, in a mechanical sense, because there is no motion. The most familiar example of work is the raising of weights against the resistance of gravity. Work is done in raising the building stone from the ground to its resting place in the wall; in raising water from the reservoir to the tank or stand pipe; or in hoisting coal and ore from the mine to the surface.

It is evident that the amount of work done depends upon the force, and also upon the distance through which the force acts. For example, twice as much work is done when 2 tons are lifted 20 feet as when 1 ton is lifted 20 feet; three times as much work is required to lift a ton 30 feet as is required to lift it 10 feet. Work, therefore, is measured by the product of the force by the distance. The unit of work is the foot-pound, which, as its name indicates, is the work done in raising a weight of 1 pound through a height of 1 foot. Using the foot-pound as a unit, the work in foot-pounds is the product of the force in pounds by the distance in feet.

Thus, to raise a stone weighing 85 pounds from the ground to the top of a wall 22 feet high requires $85 \times 22 = 1,870$ foot-pounds of work. If a carpenter exerts a force of 20 pounds, and pushes his plane a distance of 3 feet, he performs 60 foot-pounds of work during the operation. If it requires a steady pull of 80 pounds to keep a cart in motion, the work performed in drawing the cart 200 feet is $80 \times 200 = 16,000$ foot-pounds.

In nearly all cases the motion is in the direction of the force producing it. Occasionally, however, this is not true, and this fact must be considered in measuring the work. In Fig. 1, suppose a body, resting on a flat surface, is acted upon by a force F, which makes an angle of, say, 30° with the

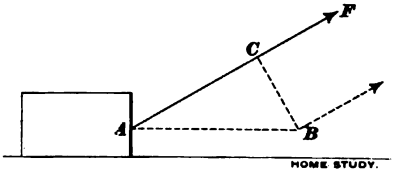


FIG. 1.

surface. Imagine, for instance, that the body is a heavy chest upon a floor, which a man is pulling along by a rope. Now, the chest does not move in the direction $A F$ of the force, but slides along the floor in the direction $A B$. Suppose the body moves from A to B; the work is *not* the product of the force F by the distance $A B$; to find the work we must project the distance $A B$ upon the line $A F$, along which the force acts. To do this we draw through B a perpendicular to $A F$, cutting it at C. $A C$ is the distance moved in the *direction of the force*, and the work is the product $F \times A C$, where F is the force in pounds. We must be very sure in every case that the distance used in our product is in the direction of the force.

Before leaving the subject of work there is one more point to be studied. We have seen that when the force acting on a body is less than the resistance opposing the motion, the body remains at rest, and there is no work done. There are two other possible cases: (1) the acting force, or *effort*, as it is sometimes called, is just equal to or very slightly greater than the resistance; (2) the effort is considerably greater than the resistance. In every case, the work is the product of the force by the distance, but the use to which this work is put will depend upon the relation between the force and the resistance. In Fig. 2 a body B rests upon a table. To move this body along the table requires a certain force which depends on the coefficient of friction. Suppose B weighs 200 pounds, and the coefficient of friction is .25; then a force of $200 \times .25 = 50$ pounds is required to produce motion. Suppose, now, that we attach a body W, which weighs just 50 pounds, to the cord, as shown in the figure; the weight of W acts as a force tending to pull the body B along the table. Since the force tending to move the body is just equal to the resistance opposing motion, the forces neutralize each other and the body will not move. Let us, however, add a small weight, say an ounce, to W; then the force, being greater than the resistance, will start the body to moving slowly. After the motion has begun we remove the ounce, leaving the force and resistance again balanced; the body still continues to move slowly in the direction of the force. If B moves, say 4 feet, the work done by the force is $4 \times 50 = 200$ foot-pounds. To find the work expended in overcoming the resistance of friction, we multiply the resistance in pounds by the distance; in this case, the work of resistance is $4 \times 50 = 200$ foot-pounds, and is equal to the total work of the force. This could, of course, have been predicted, since the applied force is constantly equal to the resistance. Let us now attach a weight of 80 pounds to the cord. The applied force, or effort, is now 80 pounds, while the resistance is, as before, 50 pounds. If the body moves 4 feet, the work done is $4 \times 80 = 320$ foot-pounds, while the work expended in overcoming resistance is $4 \times 50 = 200$ foot-pounds. We inquire what has become of the 120 foot-pounds, the difference between the work of the effort and the work of resistance? The explanation is simple: When, as in this case, the effort is greater than the resistance, the body is acted upon by a constant unbalanced force, which causes it to move continually faster and

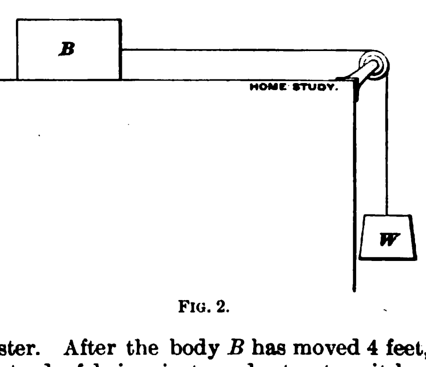


FIG. 2.

faster. After the body B has moved 4 feet, instead of being just ready to stop, it has acquired a considerable velocity. A moving body is capable of doing a certain amount of work in coming to rest; thus, suppose that, after the body B has moved 4 feet, the string is cut; it will be found that B has a velocity that will carry it on 2.4 feet farther against the opposing resistance of friction; that is, the body in coming to rest does $2.4 \times 50 = 120$ foot-pounds of work. This

work, which a moving body has stored up in it, is just the difference between the work of the effort and the work of the resistance. The usual name given to this stored work is *kinetic energy*. We therefore have the fundamental equation:

The work of the effort = the work of the resistance + the kinetic energy.

Denote the effort by P, the resistance by R, the distance moved by s, and the kinetic energy by K;

then $$Ps = Rs + K,$$
or $$K = Ps - Rs = s(P - R).$$

From the equation we see that the stored work or kinetic energy is always equal to the distance multiplied by the difference between the effort and resistance. In case the resistance is equal to the effort, we have $K = s(P - P) = 0$, and there is no stored work. Sometimes the resistance is greater than the effort: the formula shows that the work must be negative. An example is shown in the stoppage of a railway train; the resistance is increased by the application of the brakes until it exceeds the pull of the locomotive, which is the effort. This immediately causes a decrease in the work stored in the moving train, which, of course, reduces the speed of the train. To state the idea more clearly, the train has a certain stored work which must be gotten rid of before the train comes to rest. Closing the throttle removes the effort, and putting on the brakes increases the resistance. The stored work is rapidly expended in overcoming the resistance of the brakes, and as soon as it is exhausted the train stops.

The work done during a given operation depends in no way upon the time spent in the performance; thus, to raise a building stone weighing 500 pounds to the top of a wall 12 feet high requires $500 \times 12 = 6{,}000$ foot-pounds of work, whether done in a minute or in half an hour. It is necessary, however, to take the time into account when we consider the apparatus which does the work. If one apparatus lifts the building stone in 1 minute, while another requires 5 minutes, we say that the former is 5 times as powerful as the latter; that is, the *power* of a mechanical agent is measured by its *rate* of doing work or the work it can do in 1 minute. Power, then, may be defined as the *rate of doing work*. There are two units of power: the foot-pound per second, and the *horsepower*. Suppose the building stone mentioned above is raised in one-half minute, or 30 seconds: the work is 6,000 foot-pounds, and the rate of doing the work or the power exerted by the lifting force is $\frac{6{,}000}{30} = 200$ foot-pounds per second. The foot-pound per second is too small a unit for practical purposes; a large engine, for example, has a power of perhaps a million or more such units. For this reason the unit of power in common use is the *horsepower*. This unit was devised by Boulton and Watt in rating their steam engines. The average horse can exert a steady pull of 100 pounds at a pace of 4 feet per second for a day of 10 hours; this gives a power of 400 foot-pounds per second. The experiments of Boulton and Watt were made upon the strong dray horses of London, which were capable of performing 550 foot-pounds per second, at least for short intervals. The horsepower was therefore fixed at 550 foot-pounds per second, or 33,000 foot-pounds per minute. The horsepower exerted by an agent is found by dividing the work done per second by 550, or the work done per minute by 33,000. For example, if a locomotive is exerting a pull of 6,000 pounds on the drawbar at a speed of 30 miles per hour, or 44 feet per second, the work per second is $6{,}000 \times 44 = 264{,}000$ foot-pounds, and the horsepower exerted by the locomotive is $264{,}000 \div 550 = 480$.

The following general formulas may be used in horsepower calculations:

Let P = effort in pounds;
s = distance in feet in the direction of the effort;
t = time in seconds;
T = time in minutes;
H = horsepower.

Then $$H = \frac{Ps}{550\,t},$$
$$H = \frac{Ps}{33{,}000\,T}.$$

The distinction between power and work lies in the time element which enters into questions of power. When we inquire about the power of an engine or motor, we do not say "how much work does it do," but "how much work does it do per minute or per hour?" To say that power is force multiplied by distance, or that a horsepower is 33,000 pounds lifted a foot high is nonsense. If the 33,000 pounds are lifted a foot in 1 minute, the lifting agent exerts a horsepower; if they are lifted in 2 seconds, 30 horsepowers are exerted. As soon as we know the time taken to accomplish a certain work, we can determine the power; not before.

In the simple case of raising weights, the computation of horsepower is readily effected by the general formulas; there are, however, many special cases of practical importance in which a modification of the general formula is to be preferred. A case which frequently occurs is that in which either the effort or resistance is a fluid pressure; this case we will now consider.

In Fig. 3, a piston is moving in a cylinder under the pressure of a fluid. The piston rod transmits the work done on the piston,

FIG. 3.

perhaps to a piston in another cylinder, as in the steam pump or air compressor, perhaps through suitable mechanism, to a shaft, as in the steam engine. In any case, we shall assume that the resistance which the rod encounters is just equal to the effort on the piston, which is usually the case in practice. Suppose that the pressure in the end M of the cylinder is p_1 pounds per square inch, and in N, p_2 pounds per square inch. If A be the area of the piston in square inches, it is plain that the net effort urging the piston to the right is $(p_1 \quad p_2)A$ pounds. Call the net pressure per square inch, p; then the effort is $P = (p_1 - p_2)A - p\,A$. Letting L represent the distance traveled by the piston in one stroke, the work done by the piston in moving from one end to the other is the effort multiplied by the distance, or $p\,A \times L = p\,A\,L$ foot-pounds. Now, A is the area of the piston in square inches; therefore, $\frac{A}{144}$ is the area in square feet. If this area is multiplied by L, the length of the cylinder, the product is the volume of the cylinder in cubic feet; that is, $L \times \frac{A}{144} = V$, or $L\,A = 144\,V$, where V is the volume. Substituting this value of $L\,A$ in the previous expression for the work, we have: work $= 144\,p\,V$. If we take the pressure in pounds per square *foot* instead of in pounds per square *inch*, the expression is: work $- p\,V$.

In words, the work done by a moving piston is the product of the net pressure acting on it, in pounds per square foot, by the volume in cubic feet swept through by the piston. To the previous short definition, *work is force multiplied by distance*, we may add the following, which applies in cases of fluid pressure: *work is pressure multiplied by volume.* It is to be noticed that, when work is computed by the pressure-volume method, the relative dimensions of the cylinder do not enter into the question; so long as the volume is known, it does not matter whether the cylinder is long and of small diameter or short and of larger diameter; the work done per stroke is the same.

We are now prepared to develop formulas for computing the work and horsepower for any case that may arise. First, let us take the steam engine: we have seen that the work done per stroke is $p\,A\,L$ foot-pounds; if the number of strokes per minute be denoted by N, the work done per minute is $p\,A\,L\,N$, or, as it is usually written, $p\,L\,A\,N$. Denoting the horsepower by H, we have,

$$H = \frac{\text{work per minute}}{33{,}000} = \frac{p\,L\,A\,N}{33{,}000}.$$

In this formula, L must be taken in feet; if p is taken in pounds per square inch, A must be taken in square inches; if p is taken in pounds per square foot, A must be expressed in square feet. We will next consider the case of a fan or blower, which delivers air under pressure. Let Q represent the volume of air in cubic feet discharged per minute, and p, the pressure in pounds per square foot; then the work done per minute is $p\,Q$ foot-pounds, and the horsepower is given by the formula,

$$H = \frac{p\,Q}{33{,}000}.$$

To gain a clear conception of how the work is done, we may imagine a piston a placed in the discharge pipe b (Fig. 4). The piston is moved to the right by the pressure generated by the revolution of the fan. Denoting this pressure per square foot by p, and the area of the pipe by A, the total effective pressure urging the piston is $p\,A$. Suppose the piston travels L feet in 1 minute; the work per minute is $p\,A \times L$, or $p\,A\,L$ foot-pounds. But $A\,L$ is the number of cubic feet swept through by the piston, and must be the number of cubic feet of air pushed out per minute by the piston; that is, $A\,L = Q$, and the work done per minute is $p\,A\,L - p\,Q$ foot-pounds. In the actual machine there is no piston, as we have imagined. We may, however, consider any

thin slice of air as a sort of piston urging on the air in front of it. As a numerical example, let us compute the horsepower of a fan which delivers 4,000 cubic feet of air per minute, at a pressure of 3 ounces per square inch. The pressure per square foot is $\frac{3 \times 144}{16} = 27$ pounds; then the work done per minute is $27 \times 4{,}000 = 108{,}000$ foot-pounds, and the horsepower is $108{,}000 \div 33{,}000 = 3.27$.

The steam pump furnishes an instructive exercise in the computation of work. The effort is the pressure of the steam in the steam cylinder, while the resistance is another fluid pressure — that of the water in the discharge main. Neglecting the friction of the mechanism, the effort and resistance must be equal, as there is little or no stored work in the water discharged; consequently, we can compute the theoretical work from the known resistance due to the water pressure. Let h denote the height in feet to which the water is lifted, measured from the center of the cylinder; p, the pressure in pounds per square inch against the water piston due the head h; V, the volume in cubic feet swept through by the water piston in one stroke; and W the weight of water discharged during one stroke. The work per stroke is as usual, $144\ p V$ foot-pounds, the 144 being used because the pressure is taken in pounds per square inch. The pressure, however, is found from the head h, as follows: A cubic foot of water weighs $62\frac{1}{2}$ pounds; therefore, a column of water 1 foot high and having a cross-section of 1 square foot weighs $62\frac{1}{2}$ pounds, or a column of water 1 foot high exerts a pressure of $62\frac{1}{2}$ pounds per square foot on the base of the containing vessel. This is equivalent to a pressure of $\frac{62.5}{144} = .434$ pounds per square inch; therefore, to find the pressure in pounds per square inch due to a head of water, we multiply the head in feet by .434; that is, $p = .434\,h$. Substituting this value of p in the above expression, the work per stroke is $144 \times .434\,h \times V$. Now this expression for the work may be interpreted in two ways: We may consider $144 \times .434\,h$ as one factor and V as the other, and say that the work is the product of the pressure per square foot, which is $144 \times .434\,h$, by the volume V; or, we may consider h as one factor and $144 \times .434 \times V\ (= 62.5\ V)$ as the other. Since a cubic foot of water weighs 62.5 pounds, the product $62.5\ V$ is the weight W of the volume V of water discharged per stroke. Considered in this light, the work per stroke is $W h$, the product of the weight of water moved by the height of the lift. This result might have been arrived at directly, since the action of the pump consists simply in lifting at each stroke a cylinder full of water through a height equal to the head. Denoting the number of strokes per minute by N, the horsepower of the pump is given by the formulas,

$$H = \frac{144\,p\,V\,N}{33{,}000},$$

or

$$H = \frac{W\,h\,N}{33{,}000}.$$

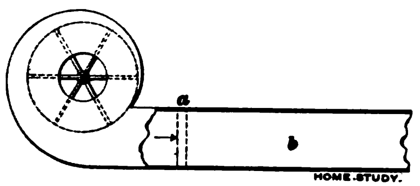


FIG. 4.

In the examples given, we have assumed that the effort is just equal to the resistance, so that no work is stored in the moving bodies. This is usually the case in machines or motors which run continuously; thus, in the case of the steam engine, the working force, that is, the steam pressure on the piston is, by the governor, automatically kept equal to the varying resistance. Many problems arise, however, in which the force is greater than the resistance during a definite period of time. For example, a railway train starts from the station, and in a few minutes acquires a speed of 40 miles an hour; at this speed the train has a large amount of stored work, and in order that this work might be stored, the pull exerted by the locomotive on the drawbar must have been in excess of the resistance due to friction, etc. As soon as the train attains a uniform speed, the storing of work ceases, and the force and resistance become equal. The computation of work and horsepower, when stored work is taken into account, is not more difficult than in the ordinary case, but it lies beyond the scope of this article.

NOTES ON CONTINUOUS-CURRENT MOTORS.

Herman A. Strauss.

RATING—THE MOTOR CIRCUIT—SETTING UP AND RUNNING MOTORS.

RATING.—Continuous-current motors are rated according to the amount of horsepower available at the pulley end, when the motor is running at its normal speed.

It is a well known fact that no machine can "give off" the same amount of power to do useful work as it takes in, because there are always friction losses in the moving parts, which absorb part of the power transmitted through the machine. In an electric motor there are, besides friction losses, other losses, such as those caused by the heating of the conductors through which the energy is passing. Therefore, to cause an electric motor to give off at its pulley end a certain amount of power, a *greater* amount must be supplied at the commutator end. The power supplied at the commutator end may be termed the *input* of the motor, and the power which can be taken out (i. e., delivered) at the pulley end, the *output* of the motor. The difference between the *input* and *output* is evidently the power absorbed by the motor, and is regarded as a loss.

Practice has shown that in large, well designed motors this loss may be brought down to less than 10 per cent. of the input. In some motors, however, notably street-car motors, the loss is often 25 per cent., or more.

The energy supplied to the motor is measured by the product of the volts and amperes of the supply circuit, and is termed *watts*. The relation of the watt to the horsepower is such that 746 watts equal 1 horsepower. Therefore, if a motor is supplied with 200 amperes at 110 volts, the equivalent energy is $110 \times 200 = 22{,}000$ watts, and the input in horsepower is $\frac{22{,}000}{746} = 29.5$ H. P.

If this same motor develops 25 useful horsepower at the pulley end, the loss in the motor is evidently $29.5 - 25 = 4.5$ horsepower. This 4.5 horsepower is absorbed by the friction of the moving parts, the heating of the conductors, etc., etc.

The commercial efficiency of the motor may be defined as the ratio between the power supplied and the power delivered; that is,

$$\text{commercial efficiency} = \frac{\text{output}}{\text{input}}.$$

In the above case, the commercial efficiency would be $\frac{25}{29.5}$ = about 85 per cent. This efficiency can also be expressed by the ratio of $\frac{\text{watts output}}{\text{watts input}}$; or, since 25 horsepower $= 25 \times 746 = 18{,}650$ watts, the efficiency would be $\frac{18{,}650}{22{,}000}$ = about 85 per cent., as before.

A line of continuous-current multipolar motors is given in the table, for which the general data above referred to has been calculated and tabulated.

By consulting this table we note at once that the efficiency (given in column 8) increases in general with increasing size of motor, but we also see that there are some exceptions to this rule. Furthermore, we note that the speed decreases in general with increasing size. The efficiencies given in column 8 may be regarded as approximately the general value of the efficiency for all motors of this type, having their respective capacities given in column 1.

In column 9 the amount of power absorbed by the various motors is given. A study of this column shows that for large motors this loss may reach a high figure, as for instance in the 290-horsepower 500-volt motor, where the loss is nearly 35 horsepower.

Column 4 is a very useful column when the wiring of the motor circuit is to be determined, because it shows at a glance the maximum current which such wiring must carry.

The table will also be found useful for making determinations such as the following:

If the installation of a motor is contemplated which must deliver 25 horsepower to a countershaft, it is evident that since the efficiency of this motor is about 85 per cent.,

1	2	3	4	5	6	7	8	9
Output Horse-power.	Output Watts.	Revolu-tions per Minute.	Input Amperes.	Input Volts.	Input Watts.	Input Horse-power.	Commer-cial Efficiency = Output / Input	Loss Horse-power Absorbed by Motor.
		1,500	5.5	110	605	.81	617	.31
½	373	1,600	2.7	220	594	.80	.625	.30
		1,700	1.2	500	600	.80	.625	.30
		1,000	26.5	110	2,915	3.9	.77	.9
3	2,238	1,000	13.0	220	2,860	3.8	.79	.8
		1,075	5.5	500	2,750	3.7	.81	.7
		900	42	110	4,620	6.2	.81	1.2
5	3,730	900	21	220	4,620	6.2	.81	1.2
		1,000	9	500	4,500	6.0	.83	1.0
		800	85	110	9,350	12.53	.80	2.53
10	7,460	800	42	220	9,240	12.38	.81	2.38
		875	18.5	500	9,250	12.40	.81	2.40
		625	121	110	13,310	17.84	.84	2.84
15	11,190	625	59	220	12,980	16.43	.91	1.43
		725	26	500	13,000	17.42	.86	2.42
		575	160	110	17,600	23.58	.85	3.58
20	14,920	575	79	220	17,380	23.29	.86	3.29
		650	35	500	17,500	23.45	.85	3.45
		550	200	110	22,000	29.48	.85	4.48
25	18,650	550	97.5	220	21,450	28 74	.87	3.74
		600	43	500	21,500	28.81	.87	3.81
		425	275	110	30,250	40.54	.86	5.54
35	26,110	425	134	220	29,480	39.50	.89	4.50
		475	59	500	29,500	38.53	.91	3.53
		400	365	110	40,150	53.80	.88	6.80
47	35,062	400	181	220	39,820	53.36	.88	6.36
		450	80	500	40,000	53.60	.88	6.60
		375	456	110	50,160	67.21	.86	9.21
58	43,268	375	224	220	49,280	66.04	.88	8.04
		425	98	500	49,000	65.66	.88	7.66
		400	525	110	57,750	77.39	.91	7.39
70	52,220	400	263	220	57,860	77.53	.90	7.53
		600	115	500	57,500	77.05	.91	7.05
		500	630	110	69,300	92.86	.92	7.86
85	63,410	500	315	220	69,300	92.86	.92	7.86
		325	137	500	68,500	91.79	.93	6.79
		400	850	110	93,500	125.29	.92	10.29
115	85,790	400	427	220	93,940	125.88	.92	10.88
		550	186	500	93,000	124.62	.93	9.62
290	216,340	350	1,100	220	242,000	324.28	.90	34.28
		375	485	500	242,500	324.95	.89	34.95

it will require $\frac{25}{.85} = 29.5$ horsepower to drive the motor.

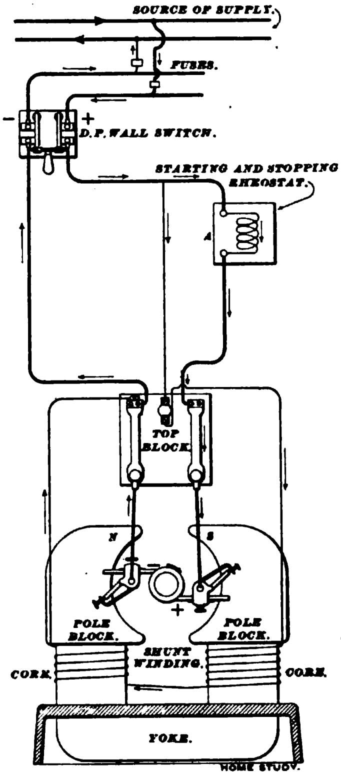
If on the other hand we have an electric circuit from which we can take, say, 500 volts and 80 amperes, that is, 40,000 watts, or $\frac{40,000}{746} = 53.5$ horsepower, and we desire to order an electric motor to utilize this power, then we must allow in the neighborhood of 15 per cent. for losses in the motor, which, deducted from 53.5 horsepower, leaves 45.5 horsepower. We would therefore order a 45 horsepower motor.

The Motor Circuit.

In the accompanying figure the general connections and the wiring circuit of a shunt-wound, constant-potential, continuous-current, bipolar motor are shown. This is the type of motor in common use to which all the data of the preceding table will in general apply, although that table is laid out for a line of multipolar motors.

The distinguishing characteristic of this type of motor is the fact that it will run at fairly constant speed, if the voltage is kept constant, even though the load may vary considerably.

Such a motor is, however, not adapted to starting with an abnormally heavy load, as is required of the ordinary street railway motor. But for running countershafting or machine tools, directly, it is the most desirable motor, because for such work, while constant speed is absolutely essential, no load other than the power required to rotate the tool itself is demanded until the motor has gained its headway. Then the load is brought on; this load consists of the work which the tool is designed to perform, and may be any one of the ordinary operations of turning, planing, drilling, boring, etc., etc.



The circuit of the motor in the figure shows that the current coming from the source of supply passes through a fuse, and then to the main switch. From the positive (+) side of the switch, two wires are carried to the motor. The one wire is the main lead (shown in heavier line) and is carried through the starting and stopping rheostat before reaching the (+) armature terminal. This is done to avoid too great an inrush of current when starting the motor. The second lead runs directly to the shunt winding and is connected to the main lead before the current passes through the starting box, so that the field may at once become strongly magnetized.

The two currents now traverse respectively the armature and the fields of the motor, and emerge on the negative side of the machine. Here the left shunt winding is permanently connected to the negative (—) brush, by being connected to the so-called terminal board, or top block, which is usually attached to the top of the machine. The main negative lead, however, is carried from the terminal board back to the main switch and thence again to the source of supply, thus completing the circuit.

The starting and stopping rheostat, it should be added, has attached to it a hand lever, by means of which the quantity of resistance introduced in the circuit may be varied or cut out altogether.

Setting Up Motors.

The motor should be set up in a dry place, free from dust and flyings, on a foundation of wood, raised at least eight inches above the surrounding floor. It should be placed with its shaft level and in line with the shaft to be driven, so that when it is running the armature will play back and forth endwise, through a short space, always allowed in the setting of the collar at the pulley end of the shaft. This lateral motion is quite important for the smooth and even wear of the bearings and of the commutator.

See that the nut on each brush stud is screwed tight, so that the stud cannot turn. Set the brush holders in position on the stud, secure the adjustment arm by setting the screw in its hub tightly on to the stud with a screwdriver. Be careful that the holders are perfectly free, and when two or more holders are placed on one stud, see that they are set so as not to rub against each other, but have a small clearance. If the brushes are of copper, set them to a position that will wear a bevel of about 45 degrees at their ends. See that the spring is adjusted to give the holder a sure pressure forward.

The important point to observe is, to set the adjustment arm rigidly on the stud, at the point where a light and sure contact of the brush with the commutator is secured. The points of the brushes on the two studs are to be placed diametrically opposite to each other. Adjust the brush lever by trial when the motor is running, and set it where the least spark appears at the brushes.

If woven-wire brushes are used, they may be allowed to wear their own level. They

may be turned over occasionally so as to keep the bevel about equally worn on both sides; this will obviate the necessity of filing.

If carbon brushes are used, it is necessary that they should be very carefully fitted to the curvature of the commutator. Carbon brushes generally give less trouble than copper brushes, as they do not wear the commutator so much, nor do they spark so readily. A carbon brush should be free from the slightest crack or flaw, and a hard corner should not be allowed to come in contact with the commutator.

With a little care as to the pressure of the brushes, a commutator may be made to acquire a dark, polished appearance, which will enable it to run for a long time with very little wear of the brushes and commutator. In case the commutator appears to be getting rough, use some fine sandpaper to smooth it when running. Fold the sandpaper over a small block of wood to make the segments even.

Never use a file on a motor commutator when current is on.

Never use emery cloth on a commutator.

Never allow a screwdriver or any metal whatsoever to bridge from one binding post to another, otherwise the machine may be short-circuited and the armature wrecked.

Never allow the machine to become dirty, and see that all the running parts are always well lubricated.

RUNNING MOTORS.

The motor should be carefully examined before it is set running the first time. Remove the caps of the bearings, and clean the bearings and journals. Replace them, but do not screw them down too tightly. See that the lubricators are filled and that their drip is properly adjusted. If the bearings are self-oiling, see that the oiling rings work properly. If possible, turn the armature around by hand for a turn or two, to see that nothing catches and that no loose wires or waste are adhering to it. Clean the commutator, and note carefully that no dirt or copper dust is lodged between the bars of the commutator. Before closing the main switch, however, make sure that all the resistance of the starting box is in circuit. Then close the switch quickly. If the motor is in perfect condition, the connections well made, and the wiring correct, the armature will be set into rapid rotation. Now go to the starting box, and slowly but gradually cut out the resistance, by moving the lever arm across the contacts. With every contact passed, the speed of the motor is sensibly increased until, when this resistance has all been cut out, the motor is running at its normal speed. Under no circumstances allow part of the resistance of the starting box to remain in circuit, because these boxes are not usually designed to carry a large current for any longer time than a few minutes; and if left longer in circuit, the resistance coils are apt to become overheated or burned out.

In order to stop the motor, however, the first thing to be done is to again bring the entire resistance of the rheostat into the circuit, in exactly the same manner that it was taken out, namely, by slowly but gradually moving the lever arm back across the contacts, until all the resistance has been again introduced. As soon as this has been done, open the main switch and the armature will at once slow down to rest.

It is true the motor could have been brought to stop without bringing the resistance into the circuit, by simply opening the main switch, but such a proceeding would have caused a large and destructive arc at the switch terminals.

It is therefore of the greatest importance in starting or stopping such a motor, that strict attention be given to the operation of the rheostat, so that the machine may not suffer by careless or ignorant handling of the circuit.

The fuses shown just above the switch are intended to protect the motor from an abnormal flow of current, which might destroy the machine. These fuses are usually designed to blow, and open the circuit when the current reaches a certain fixed percentage above its normal value.

When such a fuse has blown while the motor is in operation, the main switch should be immediately opened and the rheostat thrown into circuit before any attempt is made to replace the fuse. After it has been replaced proceed in starting in the same manner as above instructed.

THE IMPULSE WATERWHEEL.

C. P. Turner.

THEORETICAL WORK THAT FALLING WATER CAN DO—RELATION BETWEEN HEAD AND PRESSURE. EXPERIMENTS SHOWING PRESSURE PRODUCED BY IMPACT OF A JET OF WATER.

As mechanical engineers become better acquainted with the laws governing the action of natural forces and the application of these laws to the design of machines for so directing these forces, as to make them do the world's work, they learn that the best results are generally attained by the most simple and direct mechanical construction. Every unnecessary joint and moving piece in a machine is recognized as being not only an addition to its first cost, but also an added element of weakness, of future expense for repairs, and of loss in the energy absorbed in overcoming frictional resistances. One of the best examples of the application of this principle is the impulse waterwheel, a machine for utilizing the energy of falling water, in which a correct application of the laws of hydraulics is combined with simplicity of construction, efficiency, and a thorough adaptability to its work.

One of the oldest and best known types of this motor is the Pelton waterwheel, and in many cases the impulse wheel is best known by that name; there are, however, several different makes, varying slightly in details of construction, but all acting on the same principles as the well known Pelton wheel, and we will confine the descriptive matter of this article to that particular type.

Before trying to explain the action of the water on the vanes of an impulse wheel, we will review some of the general principles of hydraulics relating to the flow of water under pressure, from a nozzle or orifice; including the relation between fall (or head) pressure, velocity of flow, and energy, or capacity for doing work.

If we have a given weight of water at rest at a given elevation, the energy of the water in foot-pounds (the unit commonly used) is equal to the product of the weight of the water in pounds multiplied by the elevation in feet. This is the capacity the water has for doing work when it is allowed to fall to the lower level, and the object of all hydraulic motors is to provide a means for transferring the energy from the falling water to the machines where it is to be used. One of the oldest and most simple devices for using the energy of falling water is the overshot waterwheel (see Fig. 1). In this case the water flows into the upper buckets on the circumference of the wheel, and its weight exerts a pressure that causes the wheel to turn; the principal force that acts is the pressure due to the weight of the water in the descending buckets, a small amount of force being derived from the impulse, or blow, delivered by the

Fig 1

water as it falls from the flume into the buckets.

Now, if the water from our elevated reservoir, instead of descending slowly in the buckets of a waterwheel and giving up its energy by the pressure it exerts on the wheel, could fall freely through the same distance without meeting any resistance, it would do no work during its fall, and would therefore reach the bottom with the same amount of energy it had before starting. There would, however, be an important change in the form of this energy; instead of the *potential* energy due to its elevated position, the water would reach the bottom with a velocity depending on the height of its fall and would thus acquire an amount of *kinetic* energy exactly equal to the potential energy lost. The water, with its high velocity, might now act on a motor in such a way that its energy would be absorbed in overcoming the resistances to motion in some machine and the same amount of work might thus be done as was done when it descended in the buckets of the overshot wheel.

It is impossible, however, to utilize much of the energy of freely falling water. The resistances of the air check its velocity and break the stream into drops and spray so that it reaches the bottom of its fall with most of its energy wasted; in addition to this, it is impossible to apply the broken stream to any simple form of motor that will make use of the little remaining energy. There are also many cases in which it is desirable to place a motor in a valley and take the water from a reservoir or stream on a mountain, thus obtaining a high head and a large amount of power from the water. In such a case it would be impossible to lead the water to a point where it would have a free fall, even if such a fall could be efficiently applied. In order to meet these conditions it is necessary to make use of another set of properties and laws by means of which the water can be made to give up its energy to our motor.

It is a well known property of water that the pressure exerted by it on any unit of area of a vessel in which it is confined — no matter what the form or extent of the vessel may be — is exactly proportional to the vertical distance of the center of gravity of the given unit below the surface of the water in the vessel; in other words, we say that the pressure is proportional to the head. A cubic foot of water weighs 62.5 pounds; consequently a column of water with a section of 1 square foot and 1 foot high will exert a pressure on its base equal to its weight, i. e. to 62.5 pounds. Since the area of this base is 1 square foot, the pressure exerted on each square inch with the head of 1 foot is $62.5 \div 144 = .434$ pound, and according to the principle that the pressures exerted by a given head of water are the same in all directions and proportional to the head, we can find the pressure per square inch exerted on any surface by multiplying the head in feet on the surface by .434.

By laying a pipe from our reservoir on the mountain to the site in the valley where the power is to be applied, we will have the case of water confined in a vessel; if there is no flow through the pipe there will be a pressure on each square inch at the lower end equal to its vertical distance in feet below the surface of the water in the reservoir multiplied by .434, and this is true no matter what the horizontal distance from the reservoir or how uneven the surface along which the pipe is laid may be. If, however, water flows through the pipe, there will be a loss of pressure at its lower end due to the energy absorbed in overcoming the resistances to the motion of the water along the sides of the pipe. These resistances increase with the length of the pipe, the roughness of its surface, the number of bends and valves, and the velocity with which the water flows. If the pipe is long, rough, and crooked, and the water flows through it with considerable velocity, nearly all the energy will be absorbed in overcoming these resistances, and there will be very little pressure at the lower end. By making the pipe large in proportion to the quantity of water that flows through it and as smooth and straight as possible, these losses will be small and there will be but little loss of pressure.

The problem now is to apply this pressure to a motor so as to utilize as large a percentage of the energy of the falling water as possible. One method by which this pressure may be applied is by allowing it to act on a moving piston similar to the piston of a steam engine; with the exception of such machinery as hydraulic presses and elevators, where the motion of the piston is slow and intermittent, this method is not satisfactory or efficient, owing to the great difference in the physical properties of steam and water. Another device often used is the turbine waterwheel, in which the water acts partly by its pressure and partly by the reactions produced by changing the direction of its motion in its passage through the wheel. With high falls and small quantities of water the turbine has

serious disadvantages, and it is under just these conditions that its simple rival, the impulse wheel, gives the best results.

If we attach a nozzle to the lower end of the pipe from our reservoir, the water will flow from it in a clear-cut stream with a velocity that depends on the pressure in the pipe and, consequently, on the head. The velocity attained by any body falling without resistance through a height h is expressed by the well known formula for the velocity of falling bodies,

$$v = \sqrt{2gh};$$

if we neglect all resistances to flow in the pipe and nozzle and represent the head on our nozzle by h, the velocity of the issuing jet will be expressed by the same formula, and the water that flows from the nozzle will have the same kinetic energy that it would have had if it had attained its velocity by falling without resistance through a vertical height equal to the head h.

FIG. 2.

So far we have not considered the actual amount of energy that is represented by our jet; in order to do this we must know the quantity of water as well as the velocity or the distance through which it falls. If a is the area of the nozzle in square feet, and v the velocity of the jet in feet per second, the quantity of water in cubic feet per second is $Q = a v$. We can replace v in this expression by its value $v = \sqrt{2gh}$, and, by substituting the usual value (32.16) for g, obtain the expression $Q = 8.02 a\sqrt{h}$. The weight of water in pounds per second is then $W = 52.5\,Q = 501.25\,a\sqrt{h}$, and the energy in foot-pounds per second is $W h = 501.25\, a\, h\sqrt{h}$. We have seen that part of the energy will be absorbed in overcoming the resistances to flow through the pipe. The effect of this loss is a decrease in the pressure at the nozzle which is in effect the same as a decrease in the head that produces the velocity of flow. Let us attach a pressure gauge to a pipe just above the nozzle. When the nozzle is closed so as to stop the flow through the pipe, our gauge shows a certain pressure which, in accordance with the principle that the pressure is directly proportional to the head, corresponds to the head represented by the vertical distance of the gauge below the surface of the water in the reservoir. Our gauge may be graduated to show the head in feet directly; if, however, it shows the pressure in pounds per square inch, the head in feet may easily be found by dividing this pressure by .434. The head which represents the vertical distance of our gauge below the surface of the water in the reservoir is called the *total head.*

Now we will open the nozzle and let the water flow through it; when this is done we see that the pressure shown by our gauge suddenly falls. The difference between the heads shown by the gauge when the nozzle is closed and when it is open represents the energy absorbed in overcoming the resistances to flow through the pipe, plus the kinetic energy stored in the water in the form of the velocity with which it flows at the point where the gauge is attached. In most cases of long pipes the head represented by the velocity with which the water flows is so small in comparison to the other terms that it may be neglected, and we may assume the drop in head shown by our gauge to represent the loss in energy from resistances in the pipe.

The head shown by our gauge, when the water is flowing, is the head that produces the velocity of flow, and, consequently, the energy of the jet from our nozzle, and it is called the *effective head.* In order to utilize a large part of the energy of the water from our reservoir, we must make the effective head as large as possible; this means that the pipe must be large and smooth, and that it must run in the shortest and most direct available line from the reservoir to our nozzle.

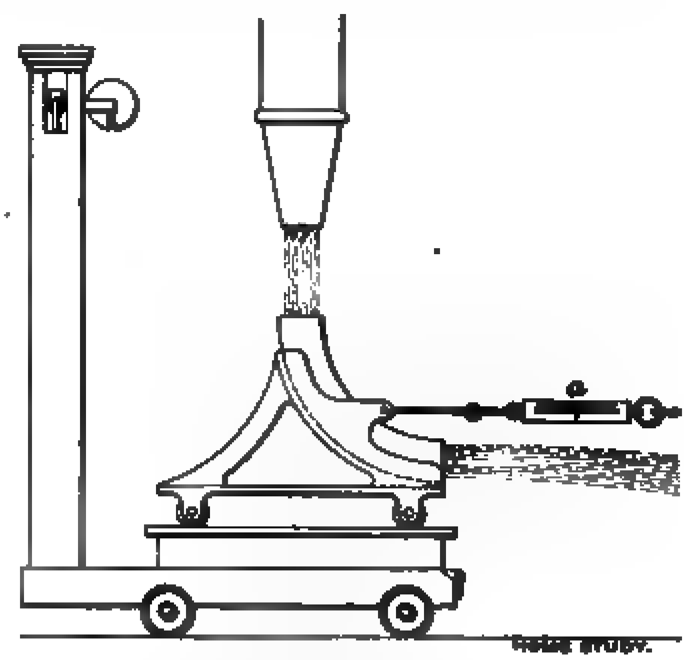


FIG. 3.

In order to understand the method by which this energy is made to do its work, we will now study the action of a jet when it strikes a surface so as to produce a change in its direction of motion.

Take a smooth piece of tin or any convenient metal and form it into a curved spout, as shown in Fig. 2, bending the spout until it forms a quarter circle. Place a light pair of scales under a nozzle, from which a jet of water will flow with a high velocity, and attach the curved spout to the platform of the scales in such a position that the water from the nozzle will flow into it in a direction tangent to its upper end, as shown in Fig. 3. Adjust the scales carefully to balance the weight of the spout; then allow the water from the nozzle to flow into it as shown.

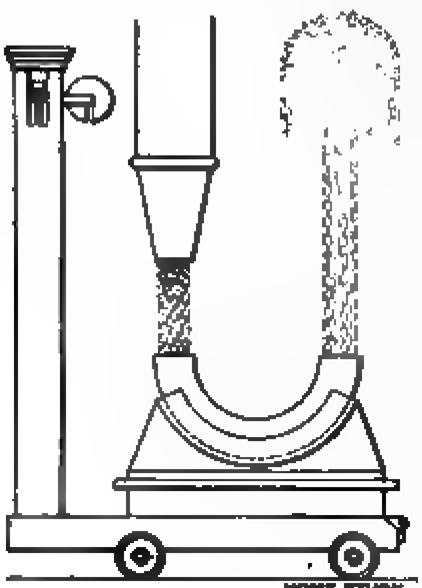


FIG. 4.

When the jet strikes the spout it is seen to flow through it and leave at the lower end with almost the same velocity with which it struck; it is also found that a very considerable weight must be added to the scale beam in order to balance the downward pressure produced by the action of the jet.

We will now repeat the experiment with a spout bent into a half circle, as shown in Fig. 4. When the jet enters this spout at one end, as shown in the figure, it is seen to pass through it and leave the other end with almost the same velocity it had when it entered; the jet that leaves the spout rises in almost as clear-cut a stream as the one that entered, and rises nearly as high as the entering jet would have risen if it had been directed vertically upwards.

This action may be seen by performing a very simple experiment that requires nothing but a round-bottomed glass, like a wine glass, and a nozzle attached to the cock of a bath-tub or kitchen sink. Hold the glass under the nozzle, as shown in Fig. 5, so as to allow the jet to enter at one side, and, if the velocity of the jet is considerable, it will flow through the glass and out at the other side, rising, like the jet from a fountain, to almost as great a height as a jet directed vertically upwards from a similar nozzle.

When we balance our scales for the downward pressure produced by the jet, in Fig. 4, we find that we must add nearly twice as much weight as was required for the case shown in Fig. 3. With the spout of Fig. 3, the direction of motion of the jet was changed through an angle of 90 degrees; the jet thus lost all its velocity in the downward direction, and was given a nearly equal velocity in a new direction at right angles to the first. A force, shown by the downward pressure on the scales, was required to destroy the original velocity; if the spout is supported on rollers, so as to move freely, and a spring balance *a* is attached, this balance shows that there is a reaction produced in giving the jet its new direction of motion, which is nearly equal to the pressure produced in destroying the old, the difference between the two being due to the losses produced by friction in the spout.

In Fig. 4, where the new direction of the jet is directly opposite to the old, the downward pressure, and the pressure due to the reaction both act in the same direction, thus giving us nearly twice as much downward pressure on the scales as we obtained with the spout, in Fig. 3.

In neither of the above experiments has our jet done any work. It has simply had its direction of motion changed, and a certain amount of pressure, depending on the change in its direction of motion, has been produced; this pressure, however, has not resulted in a transfer of the energy from the moving water to the spouts, and, neglecting the losses due to friction and shock, the water has the same amount of energy when it leaves the spouts as it had when it entered.

FIG. 5.

Now suppose we have a jet flowing from a nozzle *a*, Fig. 6, with a velocity *v*, into a

moving spout b whose velocity is v_1. If the velocity of the spout is less than that of the jet, the water will strike it with a relative velocity equal to the difference $v - v_1$ and a corresponding pressure will be produced. By attaching a cord to the spout and leading it over a pulley p, a weight w equal to

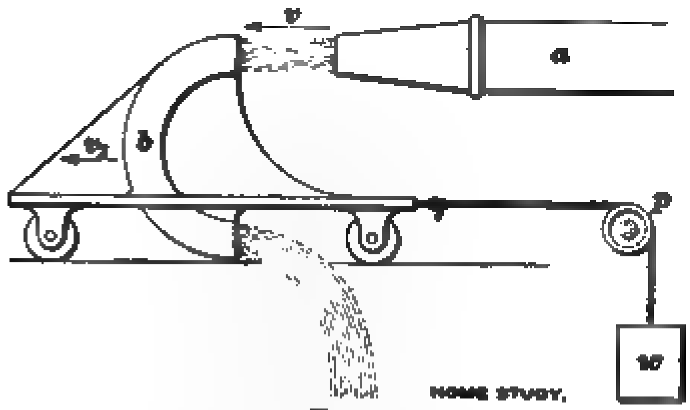


FIG. 6.

the pressure produced by the jet, may be lifted. Considering only the relative motion of the jet with respect to the spout, we see that the water strikes the spout, flows through it, and then leaves with the velocity $v - v_1$. We now have the original velocity v of the jet, the velocity v_1 with which the spout moves, and the relative velocity $v - v_1$ with which the water flows through the spout and we want to know the actual velocity of the water when it leaves the spout. This actual velocity is evidently equal to the velocity of its flow through the spout minus the velocity of the spout itself, that is, to $(v - v_1) - v_1 = v - 2v_1$. If this actual velocity can be made equal to zero, the water, when it leaves the spout, will have given up all its energy. In order that $v - 2v_1$ may be equal to zero, we must have $v = 2v_1$, from which we have $v_1 = \frac{1}{2} v$; that is, when the velocity of the spout is equal to one-half the velocity of the jet, the water, in passing through the spout, loses all its velocity and consequently gives up all its energy. The energy, however, has not been lost; it has merely been transferred from the water to the moving spout and has done the work of lifting the weight by means of the pressure exerted in producing the change of velocity. By connecting the spout to suitable machinery, as is done in the Pelton wheel described below, this energy is made to do work in much the same way as the energy of the water in the descending buckets of the overshot waterwheel does work by means of the downward pressure due to its weight.

We now come to the practical construction of the machine for utilizing the energy of our jet of water. As shown in Fig. 7 it consists simply of a wheel mounted on a shaft and provided with a set of cups around its circumference that serve the purpose of the spout in our experiment. The shaft is mounted in a suitable frame and may either be provided with a pulley, as shown in the figure, from which the power can be taken by a belt, or, if the wheel is designed to run at a proper speed, the shaft may be attached directly to the shaft of a dynamo or other machine.

The water flows from the nozzle A into the cups, flows through them in the same way as it flowed through the spout in our experiment, then drops into the tailrace below. The wheel is usually covered to prevent the water from being thrown about the room in which it is set.

The form of the cups is shown in Fig. 8. Each one is divided so as to form two

FIG. 7.

spouts, and the jet from the nozzle a is so directed as to strike the sharp V-shaped partition between them; the jet is thus split into two parts, one part passing through each division of the cup.

It will be noticed that the sides of the cups forming the outer ends of the spouts make a small angle with the direction of the jet that enters them, thus discharging

the water at an angle with the jet and away from it; while this reduces the pressure from the jet to a slight extent and makes the angle through which the direction of motion of the water is changed a little less than 180°, it is necessary, in order to discharge the water away from the wheel and prevent the water that leaves a cup from being struck by the following one.

The tops of the cups make a small angle with the radius of the wheel, and the outer sides have such a slant that the water may enter as freely as possible for different positions of the cup as it passes the nozzle. In order to prevent shock and friction, the edges against which the water strikes should be sharp and the inner surface of the cups should be smooth.

Perfect efficiency from falling water, when used in a motor of any kind, means that the water must reach the tailrace with none of the energy represented by its fall from the surface of the water in the reservoir remaining in it; i. e., it must be discharged with no velocity at the level of the tailrace. This, of course, is an ideal condition that can never be realized in practice; in the impulse wheel it is attained as nearly as is practicable by observing the following rules:

(1) Make the velocity of the cups equal to one-half of the velocity of the jet.

(2) Make the change in the direction of motion of the water in its passage through the cups as near 180° as will allow the water from each cup to clear the following one.

(3) Set the wheel near the tailrace, so as to discharge the water from the cups as near the tailrace level as possible.

The conditions just given apply to the efficient transfer of the energy from the jet to the wheel; the factors determining the theoretical energy of the jet have also been given, and we will now consider some of the conditions affecting the efficiency with which the energy of the fall, as represented by the pressure at the nozzle, is imparted to the jet. Numerous experiments have shown that the velocity of the jet from an opening, such as a nozzle attached to a large pipe, is greatly affected by the form of the opening, and the way in which the water reaches it. For use with an impulse wheel, excellent results are obtained with a conical nozzle having an opening whose area is sufficient to carry the amount of water to be discharged with a velocity equal to about .98 of the theoretical velocity due to the pressure head.

When the amount of water is variable and it is desired to utilize all the available power, a number of nozzles with openings of different sizes may be provided; by using a nozzle whose opening corresponds to the available supply of water, a maximum velocity of the jet, with a correspondingly high efficiency, may be obtained at all times.

With a variable load, the supply of water to the wheel is commonly regulated by a valve in the supply pipe. This method reduces the velocity of flow from the nozzle and, consequently, the efficiency, a part of the energy of the water being absorbed in overcoming the resistances to flow through the partly closed valve. The loss resulting from this method of regulation may be largely obviated by the use of a number of nozzles which act on the same wheel at different points of its circumference; by closing

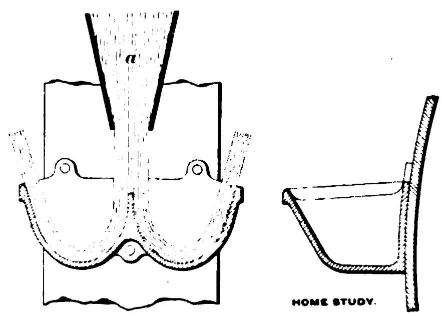


FIG. 8.

one or more of these nozzles the power developed by the wheel is correspondingly reduced, while the water from the remaining nozzles suffers no loss of velocity.

An important advantage of the impulse wheel when used under high falls is the facility with which the number of revolutions can be made to correspond with the machinery to be driven. Having a given pressure at the nozzle, the velocity of the jet, and, consequently, of the cups, is fixed; since the number of revolutions per minute is equal to the velocity of the cups in feet per minute divided by the circumference of the wheel in feet, we see that we can easily design a wheel for any desired number of revolutions by giving it the proper diameter.

We have said that the impulse wheel is specially applicable to high falls and moderate quantities of water. It is seldom used where the pressure at the nozzle is equivalent to a head of less than 50 feet; on the other hand, wheels are in use under a head of more than 2,000 feet, and there seems to be no limit to the head that can be utilized, except the strength of the materials of which the pipes and wheel are made.

HOT-WATER SUPPLY.

Thomas N. Thomson.

SINGLE- AND DOUBLE-RANGE CONNECTIONS—SUPPLY FROM KITCHEN OR LAUNDRY BOILER—METHODS OF CONNECTING UP THE RANGES TO ONE BOILER.

THE quantity of hot water used in the average dwelling house is exceedingly variable. It varies not only with the hour of the day, but also with the day of the week. The quantity, in all cases, is unknown; consequently, the size of a waterback or other water heater, employed to heat the water, also the size of a boiler to store the water so heated, can only be guessed at.

Experience has taught us that certain sizes of boilers and certain ratios between waterback heating surface and boiler capacities give certain results under certain conditions, and we plan our present and future work upon experience of the past.

If we knew the quantity of water to be heated in a given time, and the increase of temperature desired, also the condition of the fire which imparts heat to the water, we would then be able to very accurately compute proper sizes of boilers and waterbacks for different buildings.

In this article we will say nothing about the comparative sizes of waterbacks and hot-water boilers, but will rather treat upon the most common and probably the most desirable methods of fitting them up and making their connections.

Fig. 1 shows a kitchen boiler fitted up to receive hot water from the water heater *B*, commonly called a waterback. This boiler stores the hot water until it is drawn off at the faucets. This method of connecting a boiler to the waterback *B* of the kitchen range, and to the plumbing system, is the one most commonly employed in the United States.

The boiler is fed with cold water from the street main by the pipe *D*. The boiler being filled with water, the fire is started in the range, and the water in *B* which is in direct contact with the fire is thus heated. But as it is heated it rises in the pipe *E* and enters the boiler through the orifice *F*, then rises to the top of the boiler, where it remains until drawn off at the faucets through the pipe *G* or is displaced by warmer water.

The higher the temperature of the water the less dense it becomes, and the lower its temperature the denser it is; consequently, the coldest water is always at the bottom of the boiler and the hottest at the top. For this reason the pipe *G*, through which the hot water is drawn, is always connected to the top of the boiler, and the pipe *H*, which supplies the waterback *B*, to the bottom. Cold water is fed to the boiler through an inner tube *I*, which should reach down inside the boiler to a point about 3″ above the level of the top of the waterback. The reason for this is that should there ever be a partial vacuum formed within *D*, such, for example, as may be caused by fire engines

FIG. 1.

pumping water from the city mains, there will be no danger of siphoning the water in the boiler to a point below the water heater. A small hole *J* in the top of the tube is usually made to admit air to *D* and thus break siphonic action before the water line in the boiler falls too low.

The reason hot water flows from a faucet is simply because the water pressure in the boiler feedpipe forces the hot water in the boiler through the hot-water pipes and out of the faucets when they are opened, and

the quantity thus drawn off is replaced by cold water delivered into the bottom of the boiler by the inner tube *I*. Thus, it will be seen, no matter how much hot water is drawn at the faucet, it is impossible to empty the boiler in this way. The only effect will be to fill it with cold water. The pipe *K*, which has a stop-cock attached, is used only as a blow-off to empty the boiler or blow sediment from it. The lever handle of this cock should always be provided with a guard to prevent it from being opened accidently, or, the lever handle may be dispensed with and a ground key-cock having a square head used in its stead.

By the arrangement shown in Fig. 1 the reader will perceive that the waterback *B* heats all the hot water used in the building. When a set of laundry tubs are supplied with hot water from the kitchen boiler, it very often happens that the waterback cannot heat the water quickly enough to supply the increased demand on washing days, the result being that, while the building may be well supplied with hot water on ordinary occasions, the supply on wash days is far too cold.

If the heating surface of the waterback is increased to such an extent as to heat the water quickly enough to supply the demand when the laundry tubs are in use, it is generally too large for the ordinary daily usage.

To overcome this trouble then, many buildings are furnished with a separate waterback—and often with a separate boiler also—to supply the laundry with hot water. These auxiliary attachments may or may not be connected with the usual hot-water heating and distributing portion of the plumbing system. If they are intended to be operated independent of the kitchen boiler, they may be fitted up and connected to the laundry distributing pipes in a manner similar to that shown in Fig. 1. If they are intended to operate in conjunction with the kitchen boiler, the connections to both boilers will be somewhat different, because then it will be expected that either waterback will heat water for either section of the distributing piping, i. e., either to the laundry tubs or elsewhere in the building, as the circumstances require.

In Fig. 2 is shown a simple method of connecting two waterbacks to one boiler. One waterback is located in the double-oven, brick-set kitchen range *a*, and another, or a pipe coil, is located in the laundry stove *b*. In this arrangement we assume that the boiler is large enough to hold the quantity of hot water required during washing days, and that the waterback in *a* alone is not able to heat the water. The waterback or coil in *b*, consequently, is only intended to assist that in *a* during times of exceptional demands for hot water. The connections of the boiler *c* to the waterback in *a* are practically the same as those shown in Fig. 1, and the water circulates between the boiler and this waterback in the direction of the arrows shown in Fig. 1. The connections between *b* and *c* are slightly different, however. The flow pipe *d*, which conveys hot water from *b*, joins to the top

FIG. 2.

of the boiler. The reason for this is that there being no other tappings on the ordinary boiler than those to which the pipes shown are connected, the pipe *d* must join to one of the pipes, or a special hole must be cut in the boiler to receive it, unless the boiler is specially built and furnished with extra tappings. If we connected *d* to the flow pipe between *a* and *c*, the current of hot water flowing up *d* would check the flow from *a* to *c*, and the waterback in *a* would then be very liable to rattle and hammer by the formation in it of steam. Now, since the rapidity of circulation between the range and the boiler depends chiefly upon the vertical height of the flow pipe, it may seem more proper to connect *d* to the side tapping of the boiler and to connect

the flow pipe between *a* and *c* to the top of the boiler, so as to increase the circulation between the kitchen range and the boiler without injuring the circulation between *b* and *c*. Such a method of connection would no doubt furnish more hot water in a given time, and in this respect alone it would be better than the method shown in the drawing. It has a peculiar disadvantage, however, a disadvantage which is probably more pronounced than any advantage gained, and that is the fact that if the water is shut off at the stop- and waste-cock *e*, to facilitate repairs, for example, water may be siphoned from the boiler until the boiler water line reaches the small vent hole in the boiler tube. Circulation between range and boiler would then be cut off, because the water in the flow pipe, which joins the hot distributing pipe over the boiler, will not be able to rise high enough to enter the boiler. Steam would then be generated in the waterback whose circuit with the boiler is thus broken, and, no doubt, would cause trouble.

To make repairs on work when the flow pipe from the kitchen range joins over the top of the boiler, it will be necessary to "draw" or "deaden" the kitchen fire.

Such trouble is not so liable to happen when the flow pipe of the laundry stove is connected to the top of the boiler, because this stove is not always in use.

In the arrangement shown in Fig. 2, it would be well to have the boiler tappings made for 1¼″ pipe, instead of 1″, as is usually the case; then, connect with a 1¼″ × ¾″ × 1″ **T** fitting at bottom of boiler and a 1¼″ × 1″ × ¾″ **T** fitting at the top. This will allow the two circuits to join without affecting each other, and will be next best to joining them to the boiler direct.

Many plumbers fit up one boiler to two or more waterbacks, using stop-cocks or valves in the circulation pipes, the object being to shut off either circuit, as may be desired, for repairs, or when not in use.

We do not believe in the use of cocks or valves between boilers and waterbacks, because, if they are tampered with, they may be the means of waterback explosions.

In many cases they are exceedingly convenient, but there is always the danger of some meddler closing them when they should be open, or of opening them when they should be closed, and in either case a disastrous explosion may result.

GAS-ENGINE STARTERS.

E. W. Roberts.

COMPRESSED-AIR METHOD—HIGH-PRESSURE AND LOW-PRESSURE STARTERS—A GUNPOWDER STARTER.

GAS ENGINES which are too large to be easily started by hand are supplied with special devices for this purpose, known as *starters*. Much ingenuity has been expended in this line, resulting in the production of several good forms of starters. Naturally, the first method to occur to the inventor would be that of storing up air, or a mixture of gas and air, under pressure, while the engine is running, and using the same to start the engine. In case the engine has been standing idle so long as to allow the air to leak from the tank, a small hand pump may be used to get up pressure again. This method of starting turns the gas engine into a compressed-air engine for the time being, the *mixture* of course being aided in its work by being exploded. The compressed-air method has been successfully applied to one of the latest engines on the market.

A starter that was formerly used on the Clerk engine employed a stored-up mixture of gas and air, the proportions being the usual ones of the charge. The mixture is compressed by the displacer piston when shutting down. To start the engine, the crank of the motor piston is put on the inner center and the compressed mixture admitted to both the motor and displacer cylinders. The displacer crank being just beyond its center, the engine is started by the displacer piston and the pressure acts on the motor piston as soon as it passes the center. The relief valve being open, the contents of both cylinders are exhausted to the atmosphere until the motor piston passes the opening of the relief cock, and the remaining gases are compressed and exploded. This operation is usually sufficient to get the engine under way; if not, it

may be repeated, since the reservoir holds sufficient mixture for six starts.

The first Otto starter stored a portion of the burned gases during a succession of strokes. A valve between the cylinder and the reservoir was so set by means of a spring that it could be forced open with a pressure of 40 pounds. By this means, a portion of the exploded charge

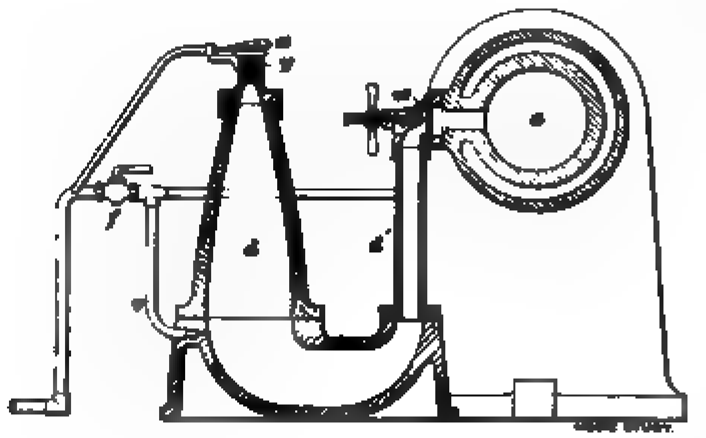


FIG. 1.

could escape to the reservoir, while the balance served to drive the engine. Connection was made with the reservoir when about to shut down and after the engine had been relieved of its load. The stored energy was afterwards used to start the engine by means of a special valve which admitted the compressed gas at every revolution. It proved to be a very efficient device.

A very successful mechanism for this purpose is that known as the Clerk-Lancaster starter, illustrated in Fig. 1. By the aid of this device the engine may be started with an explosion at full pressure and without previously storing compressed gas. The starter is operated as follows: When the engine is being stopped, and after the gas is turned off, the valve w is opened. Then, at each suction stroke, air is drawn into the chamber d through the valve y so that, by the time the engine stops, the whole of the chamber d and the pipe d' is filled with pure air at the pressure of the atmosphere. When about to start the engine, the jet x is lighted and gas is turned into d by the valve f and the pipe r. In a very short time, gas and air rush out through the valve y and the mixture is lighted by the flame x. The operator, judging by the color of the flame, closes the valve f as soon as the mixture contains the proper amount of gas and the flame rushes back in d. An explosion follows which drives the mixture ahead of it through d' and the valve w into the compression space a, compressing and igniting the charge in a and starting the engine with a high pressure explosion and with sufficient power to take up a light load.

In case the friction of the engine is small and it can conveniently be started without a load, the device shown in Fig. 2 may be used. This is known as the Lancaster low-pressure starter; it is exceedingly simple and effective, requiring but few parts in addition to those already on the engine.

When the engine is being shut down and after the gas is turned off, the cylinder a is filled with air. To start, the crank is set just far enough beyond the center to allow the engine to start when the piston receives an impulse. Gas is admitted to the cylinder by the valve f through the pipe d, and to the jet e by the valve c. The gas from d mixes with the air in a, and, at first, pure air flows out through b past the lighted jet e. When the gas escapes with the air, the mixture burns at the mouth of b, gradually changing color as the proportion of gas increases, until finally it burns with a sharp roar. At this point the operator closes the valve f, shutting off the gas from the cylinder, and the flame from b flies back into a igniting the charge. The resulting explosion closes the double-seated valve b' (see section at right of figure) and starts the engine. The next outward stroke takes in the usual charge of gas and air, but on the return, or ordinary compression, stroke, the exhaust valve is held wide open and the charge

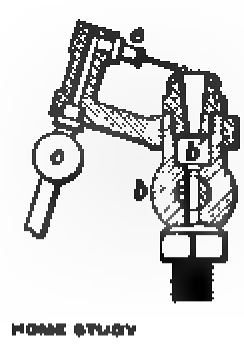


FIG. 2.

remaining is at atmospheric pressure. This mixture is fired by jet e, giving another low-pressure impulse, and the operation is repeated until the engine has sufficient headway to take up the regular cycle.

A very ingenious starter is used on the Raymond engines, and is illustrated in Fig. 3. It has three essential parts: the cartridge barrel b, the cap c, and the firing pin p. It is, in fact, a device for discharging a shot-gun cartridge into the compression space.

The cartridge used for the 40- to 75-horse-

power engines is a No. 4 brass shell, loaded, first, with about a thimbleful of rifle powder r, and then filled with FF blasting powder f. The powder is held in place by a plug of tallow t. The barrel is screwed into the wall A of the compression space with a taper thread. The cartridge is placed in b, and cap c, containing the firing pin, is screwed on b. The engineer must make sure, beforehand, that the point of p is at least $\frac{1}{32}$ of an inch back of line $x\,y$, so that it will not come in contact with the primer when the cap is screwed into place. The spring s is compressed $\frac{1}{4}$ of an inch by the nut n, in order to hold p against the seat v.

To start the engine, turn the flywheel over until the piston has compressed a charge and the crank is just past the inner center. Then strike n a smart blow with a

FIG. 3.

hammer. The explosion of the powder will fire the charge, and the combined force of both explosions will suffice to carry the engine through several revolutions until it takes up its regular cycle.

A LEVEL LINE.

Benj. F. La Rue.

DIFFERENCE BETWEEN A LINE OF TRUE LEVEL AND A LINE OF APPARENT LEVEL—THE EARTH'S CURVATURE—REFRACTION—THE PRINCIPLE OF EQUAL SIGHTS.

THE operation of leveling consists in finding the difference between the elevations of given points on the earth's surface. The difference between the elevations of two points on the earth's surface is the difference between the distances of the respective points from the center of the earth. A point is said to be *above* or *below* another point according as it is situated at a greater or less distance from the center of the earth. Thus, let $a\,b$, Fig. 1, represent, in an exaggerated manner, a portion of the earth's crust, shown in section. It is evident that the higher point or summit of the mountain s is at a greater distance from the center of the earth o than is the lower point or valley v.

In order to ascertain the difference between the elevations of any two points on the earth's surface, however, it is not necessary to know the actual distance of either point from the center of the earth.

The *difference* between the distances of the two points from the center of the earth may be determined by ascertaining their respective distances vertically above or below a horizontal or level line.

A *vertical line* is one which coincides with the direction of the force of gravity, and *vertically* means in a vertical line. The distance of any point vertically above or below a level line passing through a given point, or above or below an imaginary level line whose position is arbitrarily assumed, is called the *elevation* of the point. What is meant by a level line will be understood from what follows.

A *horizontal surface* may be defined as a surface everywhere perpendicular to the direction of the force of gravity. Such a surface is also called a *level surface*. In a very general sense, a horizontal surface corresponds to the surface of the earth. The figure formed by a perfectly horizontal surface is, therefore, very nearly that of a true spheroid. For most purposes, however, it may be considered as a sphere. The surface of a body of water at rest is a very common example of a horizontal or level surface. The intersection of a vertical plane

with a horizontal surface, is a truly horizontal line. Such a line is called a *line of true level.* It is quite evident, therefore, that a line of true level is a curved line corresponding to a great circle of the earth. Although any great circle of the earth, other than the equator, is not a true circle, for all practical purposes a line of true level may be considered to be the arc of a circle whose diameter is equal to the mean diameter of the earth, which is about 7,912½ miles, although by some authorities it is taken at 7,916 and by others at 7,919 miles.

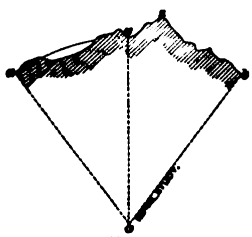


FIG. 1.

By far the most convenient method available to man for establishing a level line is by means of a *line of sight.* As we cannot sight in a curved line, but only in a perfectly straight line, because light travels only in a perfectly straight line, it follows that a line of sight cannot be a line of true level. A straight line of sight can, however, be *tangent* to the curved line forming a line of true level, in which case the former line will be truly level at the point of tangency, and at such point only. Thus, in Fig. 2, let the line ab represent a line of true level, lying in the earth's surface. The curvature is, of course, greatly exaggerated. The line ac is a straight line, or line of sight, tangent to the line of true level at a. The two lines coincide at a and at this point both lines are truly level. If an instrument were set up at a and so adjusted that its line of sight were truly level at that point, the line sighted by the instrument would be the line ac. This line, truly tangent to the line of true level, is called a *line of apparent level* and, sometimes, a *level line of sight.* Owing to the long radius and correspondingly slight curvature of the earth's surface and line of true level, the lines of true and apparent level will very nearly coincide for a considerable distance from the tangent point a.

It will thus be understood that a level line, as given by any instrument, will be the line of apparent level and will be tangent to the line of true level at the instrument. At every other point, the line of true level will be somewhat *below* the line of apparent level as given by the instrument. Thus, in Fig. 2, every point in ab, the line of true level, except the point a, is below the line of apparent level ac. At the point b, the line of true level is the distance bc below the line of apparent level. The vertical distance cb is, therefore, the correction for the earth's curvature in the sighted distance ac, to be deducted from the elevation of the point c, as given by the line of apparent level, that is, as given by any instrument.

It can be shown by geometry that

$$(ac)^2 = cb \times (cb + 2\,bo). \quad (1)$$

But $2\,bo$ here represents the diameter of the earth, and, as cb is very small compared with $2\,bo$, it can be dropped from the quantity within the parentheses without appreciably affecting the result. We may, therefore, write for the value of the correction for curvature:

$$cb = \frac{(ac)^2}{2\,bo}. \quad (2)$$

That is, the correction for curvature is equal to the square of the distance sighted divided by the mean diameter of the earth, which is about 7,912½ miles. This correction must be *added* to the elevation of a point as given by the line of apparent level ac, in order to obtain its correct elevation, the same as though given by the line of true level ab.

Thus, for a horizontal distance of 1 mile = 5,280 feet, the value of the correction cb, as found from equation (2), is as follows:

$$cb = \frac{1^2}{7{,}912.5} \times 5{,}280 = .6673 \text{ of a foot, or } 8.0076 \text{ inches.}$$

It will be near enough for most purposes to call the correction for curvature equal to 8 inches for a distance of 1 mile, or 5,280 feet. For any other distance, the correction may be obtained from this correction by proportion. Thus, for a distance of 528 feet the correction for curvature will be

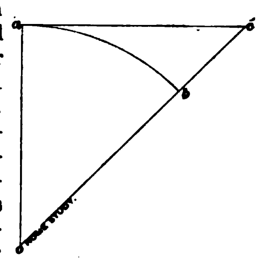


FIG. 2.

$$8 \times \frac{528^2}{5280^2} = .08 \text{ of an inch.}$$

There is also another correction which must be applied to the line of apparent level in order to obtain the line of true level, namely, the correction for refraction. Refraction is the change in the direction of a ray of light in passing obliquely from one medium into another medium of different density. The reader has probably often noticed that a stick partly submerged in

clear, quiet water in such manner as to cut the surface of the water obliquely, has the appearance of being considerably bent at the water's surface. This is due to the refraction of the light in passing from the water into the air, i. e., from a denser to a rarer medium, in traveling toward the observer's eye. If a leveling instrument be set up at a, Fig. 3, and sighted upon the line of apparent level $a\,c$, the line of sight will really be the curved or refracted line $a\,c'$. For the point c' is higher than the point a, and, as the atmosphere increases in density as it approaches the earth's surface, the rays of light, in passing from the point c' to the lower point a, are continually entering air of greater and greater density and, being always bent or refracted *toward* the denser medium, their path becomes the curve $c'\,a$, which is concave toward the earth, so that, at the point a, it assumes the direction of the straight line $a\,c$. Near the earth's surface, this curve may be considered to be the arc of a circle whose radius is 7 times the radius of the earth. At the point a, the line of apparent level $a\,c$ is tangent to the curve $a\,c'$. If an instrument be set up at a and sighted at an object which is really at c', the effect of the refraction will be to make the object appear to be at the point c, above its true position. For, while the line of sight will really be the curved or refracted line $a\,c'$, the sense of vision can recognize the line of sight only as being perfectly straight, as the line of apparent level $a\,c$ which, *at the eye*, coincides with the refracted curve $a\,c'$.

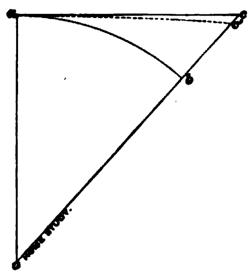


FIG. 3.

The effect of refraction is really quite uncertain, as it varies with the state of the atmosphere and may be quite different at different times. Except during unusual atmospheric conditions, however, the path of a refracted ray of light passing obliquely through the atmosphere may be taken about as stated above, that is, as having a radius equal to 7 times the radius of the earth, the radius being on the side toward the earth. The value of $c\,c'$, or the correction for refraction, may, therefore, be readily written from equation (2) by substituting 7 times the radius of the earth, or $7\,b\,o$ for $b\,o$ in the denominator of the second term or, what amounts to the same thing, by dividing the second term of equation (2) by 7, thus giving it the form

$$c\,c' = \frac{1}{7} \times \frac{(a\,c)^2}{2\,b\,o}, \quad (3)$$

in which $b\,o$ represents the radius of the earth, as before.

The correction for refraction is to be *subtracted* from the elevation of a point, as obtained by the line of apparent level. In other words, as the correction for curvature is added to the elevation of a point as obtained by the line of apparent level, the correction for refraction must be deducted from the correction for curvature, in order to give the true correction.

Thus, for a distance of 1 mile, the correction for refraction will be

$$c\,c' = \frac{1}{7} \times \frac{1^2}{7{,}912.5} \times 5{,}280 = .0953 \text{ of a foot, or } 1.1436 \text{ inches.}$$

The correction for curvature was found above to be .6673 of a foot or 8.0076 inches. Hence, the true correction is $.6673 - .0953 = .572$ of a foot or $.572 \times 12 = 6.864$ inches.

The true correction may, however, be expressed by a single formula and obtained by a single computation. For, from what has been stated above, it is evident that the true correction is represented by $c'\,b$, Fig. 3; that is, by $c\,b - c\,c'$. Hence, from equations (2) and (3), we may write

$$c'\,b = c\,b - c\,c' = \frac{6}{7} \times \frac{(a\,c)^2}{2\,b\,o}. \quad (4)$$

If, now, we let C represent the true correction, in feet, for both curvature and refraction, and also let D represent the horizontal distance $a\,c$, expressed in miles, then, by writing 7912.5 for the $2\,b\,o$, or the mean diameter of the earth, in miles, the value of the true correction for curvature and refraction, as given by equation (4), may be reduced to the following more convenient form:

$$C = \frac{D^2}{1.75}, \quad (5)$$

which is a very convenient formula for the true correction when the horizontal distance is expressed in miles, and is sufficiently correct for practical purposes.

When, however, the horizontal distance, or length of sight is small, it is more convenient to express it in feet. If we let d represent the horizontal distance, expressed in feet, then, from equation (4), we have

$$C = \frac{d^2}{48{,}741{,}000}. \quad (6)$$

This formula can be readily applied by means of logarithms.

Thus, for a horizontal sight of 1 mile, the true correction, as given by formula (5), will be equal to $\frac{1}{1.75} = .571$ of a foot. But a distance of 1 mile is equal to 5,280 feet. By formula (6), the correction for curvature and refraction will be $\frac{5{,}280^2}{48{,}741{,}000} = .572$ of a foot. The slight discrepancy of one-thousandth of a foot in these two results is due to a very slight error in formula (5). In this formula, the value of the denominator is not exactly 1.75, but is so near it, that it is given that value for convenience.

Before leaving this subject, it will be well to notice the quite important fact, that if the difference between the elevations of two given points are determined by means of a line of apparent level, or level line of sight, which is tangent to the line of true level *at a point midway between the two given points, no correction will be required* for either curvature or refraction. Thus, let it be desired to determine the difference between the elevations of the points *d* and *e*, Fig. 4. The curvature is, of course, greatly exaggerated. A leveling instrument is set up at the point *a*, midway between *d* and *e*, and adjusted upon a line of apparent level or line of vision *c a c′*. This line of vision will also coincide with the line of true level *b a b′* at the point *a*. As the instrument is midway between *d* and *e*, or *c* and *c′*, the

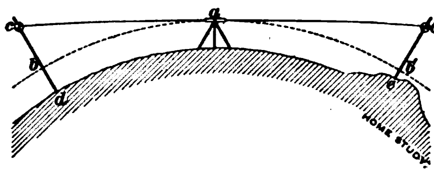


FIG. 4.

error or true correction *c b* will be the same as the error *c′ b′*. It will be evident, therefore, that the difference between the elevations of the points *d* and *e*, as measured from the line of apparent level *c a c′* given by the instrument, will be the same as though measured from the line of true level *b a b′*. This is the principle of equal backsight and foresight, recognized by all engineers in running lines of levels. It applies to the corrections for both curvature and refraction, and with proper care may be made to eliminate all such errors.

VOLT, AMPERE, OHM.

Alexander Stratton.

WHAT THESE TERMS MEAN—DYNAMOS AND MOTORS—POWER OF ELECTRICAL MACHINES—WHY ONE CURRENT WILL KILL A MAN WHILE ANOTHER WILL NOT.

THE fact that electricity is invisible—that a so-called "current" may be flowing through a wire before our very eyes without making itself known to our senses—has surrounded this force with a sort of mysticism which has led many to believe that electricity is a wild form of energy which is not subject to laws, or, if it is, that such laws are not known. On the contrary, the laws governing this force are well understood, and it is possible to calculate exactly what to expect when the conditions under which electricity is to work are given.

Although electricity is not a fluid, yet nearly all the phenomena connected with it can be explained by comparing the action of a "current" to the flow of water; and it is the purpose of this article to point out the similarity between the so-called "current" of electricity in conductors, and a current of water in conducting pipes.

In general, we may say that there are three things which affect the flow of water through pipes:

First.—The pressure under which the water is forced through the pipe.

Second.—The quantity of water flowing through the pipe during a given time.

Third.—The resistance offered to the flow of water, due to the size of the pipe, and the obstructions it may contain.

So in electricity we must consider

First.—The electrical pressure under which the electric "current" is forced along.

Second.—The quantity of electricity passing through the wire or conductor in a given time.

Third.—The resistance offered to the flow of electricity, by the conductor.

In order to measure *pressure*, *quantity*, and *resistance*, we must have *units* for comparison. Thus, the pressure to which the water is subjected we might measure in *pounds per square inch*; and the quantity of water flowing, in *gallons per second*. The unit of resistance to flow would follow from the two units just mentioned, and would be the resistance offered by a pipe of such material, length, and inside diameter as to allow *one gallon of water* to flow through it in *one second* if the water pressure were *one pound per square inch*.

The corresponding units for electricity would be, for electrical pressure, the "volt" and for electrical current, the "ampere." There is no specific name for the unit of resistance to the flow of water, but the unit of resistance to the flow of electricity is called the "ohm," and is the resistance offered by a conductor of such dimensions as to allow *one ampere* of current to flow through it when the electric pressure is *one volt*.

It is evident that if we had two volts pressure instead of one volt, and the conductor offered a resistance of one ohm, the quantity of electricity flowing through in a

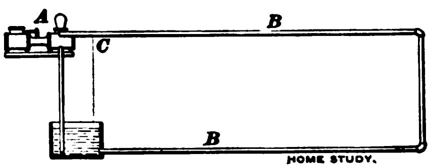


FIG. 1.

given time would be twice as much, i. e., *two amperes*. From this we see that to find out how much current will flow through a conductor whose resistance in *ohms* is known, we must divide the electric pressure in *volts* by the resistance in *ohms*, the result being the current in *amperes*. So we have

$$current = \frac{\text{pressure}}{\text{resistance}}, \text{ or } amperes = \frac{\text{volts}}{\text{ohms}}.$$

Thus, if we have a conductor whose resistance is 10 ohms, and use a pressure of 100 volts, the current will be

$$\frac{\text{volts}}{\text{ohms}} = \frac{100}{10} = 10 \text{ amperes}.$$

It is easy to see that if $\text{amperes} = \frac{\text{volts}}{\text{ohms}}$ then *volts* must equal ohms multiplied by amperes, and also, $ohms = \frac{\text{amperes}}{\text{volts}}$. So that, by knowing any two of the factors of an electric circuit, the other one can be easily determined.

Now, in order to get up water pressure we require a pump; so to get up electrical pressure we must have an "electrical pump"; but, instead of calling it by this name, it is known as a "dynamo."

If a pump is supplied with water under pressure from another pump, it can be arranged to run as a water engine, delivering mechanical energy. So, if we supply a dynamo with electric current from a similar dynamo, it will run as a "motor" and deliver mechanical energy.

Conductors and Insulators.—The space enclosed by the shell of a pipe corresponds to an electrical conductor. The shell of the pipe itself corresponds to the insulation which surrounds the conductor. The pipe prevents water from escaping; the insulation prevents electricity from escaping.

Suppose, in Fig. 1, A to be a pump forcing water through a pipe line B, which returns the water to the pump after having completed its circuit. This would represent pretty accurately an electric circuit, in which A is the dynamo, and B the conductor.

A puncture in the pipe at C will allow some of the water to escape and trickle back to the pump supply, constituting a leak. Thus all the water will not be pumped to the places where it is wanted.

This resembles a break in the insulation of an electric conductor, which gives the current a chance to leak back to the dynamo through some path where it will not be useful.

If we had a very small pipe, say $\frac{1}{32}$ inch inside diameter, and tried to force a gallon of water per second through it, it would necessitate a very great pressure and the pipe would become very warm, due to the resistance it offered to the flow of such a large quantity of water. In the same way, if we try to force a large electric current through a wire which offers a great resistance to the flow of electricity, it will require a relatively large voltage, or electrical pressure, and the wire will become very hot. Indeed, no matter how low the resistance of a conductor may be, there will always be some heat generated when an electric current flows through it, although it may be so small as not to be readily detected.

Not only does the size of the wire influence its resistance, but also the material of which it is composed.

Copper wire is one of the best conductors known, and is like a pipe whose inside surface is polished so that it offers little

resistance to the flow of water. German silver, on the contrary, offers a great deal of resistance to an electric current (about thirteen times as much as copper does), and corresponds to a water pipe partly choked up, or with a very rough interior, producing a resistance to flow, and causing a loss in pressure as the water flows along the pipe.

In Fig. 2, if the pump A is forcing water along the pipe line B under a pressure at the pump of forty pounds per square inch,

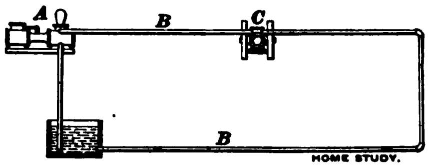


FIG. 2.

the pressure at the water engine C may have dropped down to thirty-five pounds per square inch. This reduction of pressure is due to the frictional resistance of the water against the sides of the pipe.

Similarly, when a current of electricity is transmitted along a wire, there is always a drop in pressure, due to the resistance of the conductor. Thus it may easily happen that the dynamo may be generating 125 volts, while the motor at the other end of the line may be receiving the current at a pressure of only 120 volts, the other 5 volts being lost in overcoming the resistance of the conductor.

The *power* given out by a current of water under pressure can be determined from the amount of water flowing per second, and the pressure under which it flows. A pump supplying 5 gallons per second, under a pressure of 40 pounds per square inch, will give the same power as a pump supplying 10 gallons per second under a pressure of 20 pounds per square inch. That is, if the products of the *pressures* and *quantities* are equal, the powers delivered will be the same. So in the case of the dynamo. A machine which delivers 100 amperes of current, under a pressure of 250 volts, is of the same power as one giving 200 amperes at 125 volts pressure.

No matter how large the capacity of a pump may be, it can force only a given quantity of water per second through a pipe of a given size, if the pressure is kept constant; that is to say, a pump which delivers water under a pressure of 10 pounds per square inch can force only a very small quantity of water per second through a fine pipe, even if it has the capacity of pumping 100 gallons per second through an aqueduct; for the quantity of water which can be forced through the pipe in a second is only dependent on the resistance offered to the flow of water, and the pressure under which the water is supplied.

This explains why a dynamo generating 125 volts, which is the usual pressure for lighting incandescent lamps, would not kill a man, although it may have sufficient current capacity to light one thousand 16-candlepower lamps, which require a total of about 80 horsepower.

Electrically speaking, a man is like a pipe choked up with stones and gravel, which will allow only a small amount of water to pass through it unless the pressure is very high. He offers so much resistance to the flow of the electric current that it takes at least 500 to 600 volts to force enough electricity through his body to cause death.

On the other hand, the dynamos used for lighting the arc lamps in our city streets give a very high voltage—1,000 to 8,000 volts—and one of these machines having sufficient pressure would force through the body the current necessary to cause death, even though it did not have enough current capacity to give more than a few horsepower.

There are many other cases in which a current of electricity behaves in very much the same way as a current of water flowing through a pipe, and, although strictly speaking it may seem far fetched to compare electricity to water, yet the comparison furnishes the mind with a definite idea which is sufficiently accurate to explain otherwise puzzling phenomena.

HOW TO READ A MECHANICAL DRAWING.

G. Herbert Follows.

DRAWING AS A UNIVERSAL LANGUAGE—THE ALPHABET OF MECHANICAL DRAWING—WHAT THE VARIOUS VIEWS IN A MECHANICAL DRAWING REALLY MEAN.

THERE is no need to tell our readers that the ability to read a drawing is *useful*, because they know that to them it is not only useful but *necessary*—as necessary, indeed, as is the ability to read their native language.

Everything that is made in the machine shop is made from a drawing. The drawing is made in the drafting room and is sent into the shop, where it tells its own story to the mechanic far more plainly and in much less time than any man on earth could explain it by talking. In other words, the drawing is a *language*, which the draftsman writes and the mechanic reads. Sooner or later every school in the world will teach its pupils to read and make drawings; for the language of a drawing is universal; it makes no difference whether the man who makes it be English, German, Russian, or Chinese; the drawing can be read and understood by all.

Our object in this number is to show what a mechanical drawing is, and, looking upon it as a language, to teach what may be called its *alphabet*.

Perhaps the best way to show what a mechanical drawing is, is to make evident the difference between it and a *perspective* drawing. A tracing of a photograph may be taken as a good example of a perspective

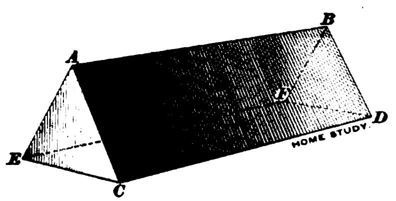


FIG. 1.

drawing, and that is what we show in Fig. 1—a shaded copy of a photograph of a prism. It explains itself just as well as though we were looking at the prism. We see at once that the edge $A\ B$ is parallel to the edge $C\ D$ and that $A\ C$ is parallel to $B\ D$. We also see that the end of the prism is triangular in shape and that the sides of the triangle are of equal length. We feel sure that all this is so because the drawing has the effect which such a prism would have if placed on the table before us.

But if we measure $A\ C$ and $B\ D$ on the drawing, we find that $B\ D$ is less than $A\ C$, so that $A\ B$ is not *drawn* parallel to $C\ D$; and

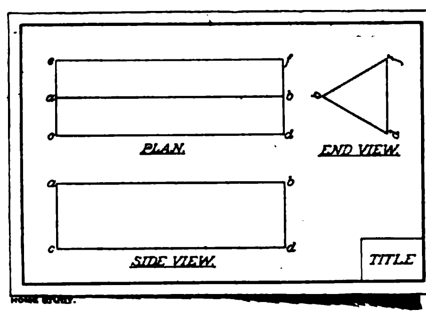


FIG. 2.

further measurements will show that the sides AE, $E\ C$, and $A\ C$ are of three different lengths. Yet, when we look at the drawing, we are convinced that it *represents* a perfectly symmetrical prism. This is because it is a perspective drawing, representing the object as it *appears*—not as it really *is*. What need then of any *other* kind of drawing? Well, with a simple piece such as the prism, this drawing would answer every purpose; the dimensions should be written upon it, and if then it were handed to the patternmaker or machinist there would be no need of further explanations. But with a complicated piece of machinery it is very different. A photograph of a lathe, for instance, would be of no earthly use to either patternmaker or machinist. A lathe has "insides," that are hidden from view, and it is anything but symmetrical; it is only by looking all around it and by taking it to pieces and making drawings of each piece separately and in position that we can inform others of its proportions and dimensions. But to return to the prism: In Fig. 2 we have a mechanical drawing of it. There are three views—plan, side view, and end view. Now,

to one who does not understand the language, this kind of drawing means practically nothing; these three views, for instance, instead of saying "prism," mean to him no more than so many senseless arrangements of lines. If he stares at them long enough he may finally come to the conclusion that the plan is a rectangle with a line down the middle, that the side view is a similar rectangle, but without any line down the middle, and that the end view is a triangle. But to the mind of the mechanic there is far more than this conveyed.

Fig. 3.

Fig. 3 is an attempt to show what Fig. 2 really means. Here we have imagined the prism to be visible through three sheets of glass that are hinged together as shown. The top plate *X* is parallel to the bottom face of the prism; the side plate *Y* is perpendicular to the top plate and parallel to the long edges of the prism; the end plate *Z* is at right angles to both *X* and *Y*, and parallel, therefore, to the end of the prism. In other words, the glass plates may be looked upon as three sides of a rectangular box, in which the prism is deposited.

Bringing the eye into position vertically over the corner *C* of the prism, we may imagine the existence of a straight line from *C* to the eye, which line will pass through the top plate at the point *c*. If we mark this point, and then bring the eye vertically over the corner *E*, we may locate point *e* in the top plate; similarly, we can locate the points *f* and *d*, *a* and *b*. By marking these points on the glass and joining *c e*, *e f*, *f d*, *d c*, and *b a*, we produce what is called a *plan* of the prism. In a similar manner, by bringing the eye horizontally in front of points *a*, *b*, *d*, and *c*, we produce the *side view* on the side plate *Y*, and, by bringing the eye in front of the end of the prism, we can, in the same way, produce the *end view* on the end plate *Z*.

All that the last two paragraphs contain is realized in a moment by the man who can read a drawing, and the drawing says "prism" just as plainly as though it had a tongue.

If now we swing the plates *Y* and *Z* upwards about their hinges, the result will be somewhat as shown in Fig. 4, which, it is evident, is precisely what we have in the mechanical drawing, Fig. 2.

Referring again to Fig. 3, the three views that we have on the glass plates are called *projections* of the prism—because each view is the shape produced by the projecting of the bounding points of the prism upon a plane (in this case a plate of glass) at right angles to the direction of projection. The imaginary lines from the prism to the plates are called projection lines, and are drawn, also, in Fig. 4. It is not customary to show these lines on a mechanical drawing, but they are always *supposed* to be there. They are, however, made frequent use of in *making* a drawing, about which more will be said next month.

Fig. 4.

(*To be Continued.*)

SQUARE ROOTS.

George McC. Robson, M. A.

LIMITS OF ACCURACY—MEANING AND IMPORTANCE OF APPROXIMATIONS—SHORT METHODS.

IN ALL physical experiments there is a limit to the degree of accuracy to which measurements can be carried; this limit varies widely in different kinds of experiments. With a good balance, a weighing can be made accurate to one part in a million; on the other hand, it requires great care to make measurements of temperature accurate to one part in a hundred. The limit of accuracy is usually expressed as a fractional part or percentage of the quantity measured. It is important to pay attention to this matter, because we frequently mislead ourselves by speaking of obtaining results correct to five or any number of places of decimals. To represent a quantity to the degree of accuracy of one part in a thousand requires a number with four digits, exclusive of the zeros which mark its position in the decimal scale. It is convenient to represent very large or very small numbers by writing down the digits with a decimal point after the first, and multiplying by that power of 10 which will fix its position in the decimal scale. Thus, the distance from the earth to the fixed star Castor is written 9.59×10^{13} miles, instead of 95,900,000,000,000 miles, while the wave length of a certain homogeneous light is written 1.55×10^{-5} of an inch, instead of .0000155 inch. Both of these quantities have been determined with the greatest accuracy attainable; hence, we see that the number of decimal places is not the way to measure the degree of accuracy; what is required, in any case, is to find a certain number of figures of the result correct. When any quantity is calculated from the results of observations, its value cannot be accurate beyond the degree of accuracy attained in the observations, and it is useless to carry the calculations beyond that degree of accuracy. It frequently happens, however, that the arithmetical processes employed to deduce the required result from the observations give a result containing more than the necessary figures. These superfluous figures are apt to be misleading; therefore, they should be discarded from the result, and generally the calculations may be much abbreviated by dropping the unnecessary figures in the course of the work.

Hence, it appears that approximations are used in calculation, not merely because it is too much trouble to work out the correct result, but because the approximate result is as accurate as the data on which it is based.

Arithmetical calculations are much facilitated by using logarithms and tables of squares, cubes, square roots, and cube roots; but sometimes it is shorter to work out the arithmetic than to use the tables. In this article are given some short methods of extracting square roots approximately; the first is the contraction of the ordinary operation of finding the square root.

Find one more than half of the figures in the root by the ordinary method.

Find the next trial divisor in the usual way; then, instead of annexing two more figures to the dividend, strike off one figure from the trial divisor. Divide the remaining part of the divisor into the dividend to obtain the next figure of the root. Then strike off another figure from the divisor, and get the next figure of the root; and so on.

EXAMPLE.—Find nine figures of the square root of 9.8696044011.

SOLUTION.—Since the number of figures in the required root is odd, we must find five figures by the ordinary method.

3	9.86′96′04′40′11	3.1415
	9	
61	86	
	61	
624	2596	
	2496	
6281	10004	
	6281	
62825	372340	
	314125	
62830	58215	

Here the trial divisor is 62,830 and the remainder is 58,215, and we proceed to apply the contraction:

```
62830) 58215 | 9265
       56547
        1668
        1257
         411
         377
          34
          31
```

Striking off the last figure from the divisor, it becomes 6,283, and 6,283 into 58,215 goes 9 times, with a remainder equal to 1,668. Striking off another figure from the divisor, it becomes 628, and 628 into 1,668 goes 2 times. In multiplying by 2, we mentally take the product of 2 and 3, and, since the product is greater than 5, we carry 1, thus the product is 1,257. Now strike off the 8, and the divisor becomes 62, and 62 into 411 goes 6 times. As before, we mentally multiply the rejected figure 8 by 6, and, since the product is nearer to 50 than to 40, we carry 5; thus we get the product 377. Striking off the 2, we find that 6 into 31 goes 5 times. Hence, correct to nine figures, we have

$$\sqrt{9.8696044011} = 3.14159265. \quad \text{Ans.}$$

The following rule is often convenient for finding an approximate value of the square root of a number that is nearly equal to a square number:

Divide the given number by the number whose square is nearest to the given number; the arithmetical mean of the quotient and divisor is the required square root approximately.

EXAMPLE.—Find the square root of 119.

SOLUTION.—The number whose square is nearest to 119 is 11.

Hence,

$$\sqrt{119} = \frac{1}{2}\left(\frac{119}{11} + 11\right) = 10.909. \quad \text{Ans.}$$

By the ordinary method, we find $\sqrt{119} = 10.9087$; so, in this example, the rule gives a result correct to three places of decimals.

EXAMPLE.—Find the square root of .9997.

SOLUTION.—The number whose square is nearest to .9997 is 1.

Hence,

$$\sqrt{.9997} = \frac{1}{2}\left(\frac{.9997}{1} + 1\right) = .99985 \text{ (correct to}$$

five figures). Ans.

This rule may be expressed in an algebraic formula; thus,

$$\sqrt{x^2 + y} = \frac{1}{2}\left(\frac{x^2 + y}{x} + x\right), \text{ approximately.}$$

To prove this, we have,

$$\frac{1}{2}\left(\frac{x^2 + y}{x} + x\right) = \frac{1}{2}\left(x + \frac{y}{x} + x\right) = x + \frac{1}{2}\frac{y}{x}.$$

Now,

$$\left(x + \frac{1}{2}\frac{y}{x}\right)^2 = x^2 + y + \frac{1}{4}\frac{y^2}{x^2}.$$

If $\frac{1}{4}\frac{y^2}{x^2}$ is a small quantity, we may neglect it, and get approximately $\left(x + \frac{1}{2}\frac{y}{x}\right)^2 = x^2 + y$.

Therefore,

$$\sqrt{x^2 + y} = x + \frac{1}{2}\frac{y}{x} = \frac{1}{2}\left(\frac{x^2 + y}{x} + x\right).$$

It can be shown algebraically that the error in using this rule is less than $\frac{1}{8}\frac{y^2}{x^3}$. Thus, to find the limit of error in $\sqrt{119}$, as calculated by this rule, we have $x = 11$ and $y = 2$; therefore, the error is less than $\frac{1}{8}\frac{2^2}{11^3}$, or .00037. So the result is correct to three decimal places, as we have already seen.

The square root of the product of two numbers is called their *geometrical mean.* This definition enables us to give another useful statement of the preceding rule: *If the difference between two numbers is small compared to either of them, then their arithmetical mean is approximately equal to their geometrical mean.*

To prove this rule, suppose the numbers are $\frac{x^2 + y}{x}$ and x; then, their geometrical mean is

$$\sqrt{\frac{x^2 + y}{x} \times x} = \sqrt{x^2 + y} = \frac{1}{2}\left(\frac{x^2 + y}{x} + x\right),$$

approximately, and this is the arithmetical mean.

EXAMPLE.—Find the geometrical mean of .318822 and .318054.

SOLUTION.—Since these numbers are nearly equal, we have

$$\sqrt{.318822 \times .318054} = \tfrac{1}{2}(.318822 + .318054)$$
$$= .318438, \text{ approximately.}$$

The limit of error may be found as before, and it will be seen that the result is correct to six decimals. In general, if the difference between two numbers is less than the thousandth part of either of them, the error in taking their arithmetical mean for their geometrical mean is less than the millionth part of either of them.

WEIGHT, OR GRAVITY.

William B. Ridenour.

WHAT SIR ISAAC NEWTON REALLY DISCOVERED WHEN HE SAW AN APPLE FALL FROM A TREE. GAY GAMBOLS ON THE MOON—DIFFICULTIES ON JUPITER.

THE investigations of Sir Isaac Newton and others into the question of gravity —or, more simply, *weight*—have a side that is at once curious and interesting. In our schoolboy days, many of us have wondered how a matter so trivial as the fall of an apple from the limb on which it had grown could have led to the discovery of any important laws pertaining to our universe. And without doubt, too, we have wondered what in the world it was that Sir Isaac did find out. Let us see. In the first place, he proved that every particle of matter attracts, and is in turn attracted by, every other particle. It follows then that what we call our weight is only the measure of the earth's attraction of the matter composing our bodies. If there were more of this matter we should weigh more; if the earth were twice as heavy as it is, our weights would be doubled.

The bodies in the solar system are many, and very different in size and density. If, therefore, we were able to make a journey amongst the other planets and their satellites, that compose this system, we should have some strange experiences in the matter of our weight. Our nearest neighbor, the moon, is only one sixty-fourth of the size of the earth. A man, therefore, whose weight here is one hundred and ninety pounds would find his lunar weight to be only three pounds. If he should retain his muscular strength, what mighty leaps he could make on her surface. Old Mother Earth is extremely careful lest some of her children should get too far away, at least in the flesh. She has a way of reaching out with her invisible hands and bringing back with much energy any one that happens to stray. On the moon, however, if returning to a home of four or five stories in height, with our latch key lost or forgotten, it would be easy to spring high enough to enter at any window of the building; or if we were in a hurry to catch a train we might make a short cut by jumping over the house in our path. The earth's gravity is sufficient to cause a body starting from a state of rest to fall sixteen and one-half feet during the first second. At the end of this time the body would have acquired a velocity of about thirty-two feet per second. Since the moon has a force of gravity of only one sixty-fourth of that of the earth, a body falling there would during the first second pass through only about three inches, and acquire a speed per second of six inches. Hence, if a person were so unfortunate as to fall from a balloon, he would have to be at an enormous altitude in order to hurt himself.

Some of the bodies that are called asteroids are only a few miles in diameter. If a strong man should visit one of them, he could kick it so far away from him as to make it necessary for him to miss several of his regular meals.

Many people amuse themselves wondering whether any other planets of the solar system are inhabited and what fashion of beings live upon them. It is very certain that the four enormous planets that are farthest from the sun can have no such beings as those that dwell upon the earth. The planet Jupiter, for example, has a volume of over thirteen hundred times that of the earth, and although its density is not so great as the earth's, the weight of a man like one of us would undoubtedly be enormous. He could not support his own weight standing erect. In order to do this it would be necessary that the texture of his body should be very ghostlike indeed.

Of the inner planets, Venus resembles the earth more closely than any other planet. Her diameter, 7,800 miles, is only a trifle less than that of the earth, and it is believed that she turns on her axis once in about twenty-four hours. Her seasons very closely resemble our own, and during their changes the telescope reveals the advance and retreat of the snow at her poles. If we were called upon to exchange worlds with the people that possibly live there, we should perhaps find ourselves very comfortably situated, and our surroundings very similar to those we now have.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Chinese Dilemma.

THERE is no community in the world so exclusive as the inhabitants of China, the "Flowery Kingdom." Across her northern frontier, dividing her from the Russian empire, is the Great Wall, nearly two thousand miles in length, erected in the dim past of more than two thousand years ago. A line of separation, dividing her from the civilized world far more effectually than any barrier of earth and stone, has been drawn around her entire boundary by the natural temperament and habit of exclusiveness of the people. In a wall there are gates, there may be breaches; its materials are perishable, and its guardians may be faithless; but whence shall come the power which shall reverse or even modify natural characteristics, as unchangeable as the skin of the Ethiopian or the spots of the leopard?

China now finds herself assailed in all directions. The powers of the world are clamoring at her gates, demanding a share in the wealth with which nature has endowed her, and which is still sealed up within her territory instead of being diffused through the channels of commerce to the mutual benefit of her own people and of the rest of the human race. Great Britian at her colony of Hongkong on the southern coast, and at Burmah on the southwest; France at Tonquin on the south; Russia at the north; Japan within easy sail of the eastern shores; Germany at her newly acquired possession of Kiao-chau on the coast, are all exerting pressure on the compact mass of China; while America stretches out her hands across the Pacific Ocean, inviting trade and commerce to flow towards the New World. China gives way reluctantly. She is not disposed to fight. Her population is enormous, but she is not prepared to offer organized resistance; and statesmen still say of her, as they said fifty years ago, that she will yield nothing to reason but everything to fear.

The opposition of the Chinese to the efforts of other nations to establish relations with them has not usually taken the form of direct and open warfare, although at times they have been obliged to take to arms as a last resort, and that unsuccessfully. They have had recourse to such means as the breach of treaty obligations, and cruel and treacherous attacks on the persons of foreigners, either merchants or Christian missionaries; and in pursuing this course they have overreached themselves, and failed to accomplish their end. China labors under the disadvantage, which is almost paralyzing at a great national crisis, of having a population of various races, with varying languages and interests. They are united by no strong national sentiment, the central government which controls their intercourse with foreign nations is corrupt and ignorant, and, like a feeble old man, desires only to live out its days in undisturbed quiet. "Peace at any price" is the cry with which such rulers naturally meet all demands.

The unjust dealing of a century or more, since the merchants of the East India Company began to trade with China, resulted in war with the British in 1840, and Hongkong was ceded to the victors. About the same time the persecution of French Christian missionaries in Annam, a tributary kingdom to the south of China, led to the acquisition by France of provinces there, and her power has gradually spread until, after several conflicts, she now virtually holds Annam, Cochin-China, Cambodia, and Tonquin, forming together a very large territory, and she is taking steps to strengthen her hold on the southern part of the country. Again, during the past year an attack on Christian teachers has exposed China to danger. The murder of two German missionaries afforded to their government the opportunity of demanding, as compensation and as a guarantee of future good faith, the cession of a tract of land which should supply the much desired basis for trade in the Eastern Seas. She claimed and China has yielded Kiao-chau Bay, the neighboring islands, and the surrounding district within a radius of thirty miles.

Russia makes her demands on China on different grounds. After the close of the

China-Japanese war in 1895, Russia stepped in and protected China from some of the worst consequences of her defeat by refusing to permit Japan to keep the province, which according to the usual custom of war, was hers by conquest. Naturally, Russia wants her wages for this service, and they are high in proportion to the value of the work done. Russia needs a port on the Pacific. Her own most southernly port, Vladivostok, is icebound during the winter months, but China has fine harbors which supply the conditions sought for by Russia. They are open all the year round; they are or can be fortified; and more than one of them would make a suitable terminus for the railway now rapidly advancing eastward, which will soon connect St. Petersburg with the Pacific. Two of these northern ports, Ta-lien-wan and Port Arthur, have just been made over to Russia on a nominal lease of twenty-five years, with rights over the adjacent lands. It is easy to guess how much chance China has of ever again including them in her dominions.

The war with Japan has rendered China vulnerable in another respect. It was a very costly war, her own national losses were great, and she has to pay to her conquerors a large sum of money as an indemnity for injuries done to them. She is poor; her people are industrious, but they live closely up to the limit of their means, and have little to spare for the liquidation of a war debt. Now, China feels the effect of her short-sighted policy in the discouragement of foreign trade. Her commerce is comparatively so small that she could not hope to raise enough for her needs by means of customs duties. She had to borrow the money, and that at once, for her creditor would not wait. Japan wants the millions which are due to her, in order to strengthen her army and her navy, and to prepare defences against future dangers. No European nation would lend the money without security, for Chinese promises to pay, in the simple form of an I. O. U., would not be acceptable.

The moneyed rulers of Europe were not unwilling to lend; in fact, some of them showed uncommon anxiety to take part in the supply of the required sum; and the various offers were accompanied by different stipulations. In some cases the practical demand was for cession of territory, the division of this valuable and fertile land amongst ambitious nations. But international jealousies interfered with the negotiations, and the loan of $80,000,000 was finally made by an English and a German bank as a private commercial transaction. With a view to securing the payment of the interest and ultimately of the principal of the debt, Great Britain has arranged with China that more treaty ports shall be established, that Chinese rivers shall be open to foreign steamboats, and that the position of Inspector-General of Chinese customs shall be held by

a British subject, as long as British trade in that country exceeds that of any other power.

The trade of Great Britain and her colonies with China in 1896 was two and a quarter times as great as that of all other countries put together. Vast sums of money are invested in this trade, and its diminution would materially damage the British empire. It is far more to her advantage that fresh ports should be thrown open to the world, and that facilities for commerce should be enlarged, than that she should acquire a slice of the country. Her policy in China is that of an open door, and of equality of opportunity for all commercial nations. If, however, other nations obtain important concessions of territory she will doubtless claim a share of the spoil. Great Britain alone amongst nations believes in and practices free trade; and therefore she does not wish to see any port of China closed to her ships and merchants, or to those of any other country. The United States recognizes the importance of this condition at the present crisis, and sees that under the system of free trade the ports of China will be open to her ships as widely as to those of any nation in the world, and not be reserved for the benefit of one country in particular.

The treaty ports are at present twenty-six in number, and are scattered along the coast and on the great waterways of China. In these ports, and in no other part of the country, foreigners are permitted by law to reside and to own houses, and here alone traffic in foreign merchandise and barter of native for foreign produce can take place. These gateways have been gradually and somewhat grudgingly opened by the Chinese. Five were ceded in 1842 as a condition of peace with Great Britain; and advantage has been taken of every opportunity to secure the right of entry to other towns well situated for purposes of trade.

The foreign population of the treaty ports is very small, consisting of not more than 10,000 persons; and of these three-sevenths are British, and one-seventh are American. Thus, more than one-half are English-speaking people, and the use of that language for purposes of trade is yearly increasing amongst the Chinese. A tariff, fixed by treaty with the British government, and limited to 5 per cent. of the value of goods, is levied on all foreign merchandise brought into the treaty ports, and in 1896 the sum realized by the government from this source was nearly nineteen million dollars. This does not represent the whole tax to which foreign goods are liable, for duty can be and is assessed whenever merchandise crosses the frontier of any one of the nineteen provinces into which China is divided. It is not easy to conceive of the inconvenience which would result from this practice if it prevailed between the States of this country, which correspond in many respects to the provinces of China.

Great Britain, France, Russia, and Germany has each its plan for bringing railroads into China. The one already in course of construction by the British starts from Mandalay, in Burmah, and will pass through the Chinese province of Yunnan, to the valley of the great river Yang-tse-Kiang. The French are planning a railroad through Tonquin to the upper valley of the Red River, also in the province of Yunnan; while the Russian Northern Railroad has already been mentioned. Germany has schemes for railroads radiating in various directions from her new possession, Kiao-chau Bay.

Means of communication in China are very inadequate to the demands of modern commerce. There are no good roads, only one important canal, and no steamboats on the fine rivers. All these must come with the advent of the foreigner, and in addition to these material improvements there must be an approach to a fair and uniform taxation, and the administration of equal justice to all, instead of the systems which now prevail, by means of which the power is in the hands of a single and largely irresponsible class. If these changes take place, China will inevitably cease to be a sealed treasure house, as she gradually, however unwillingly, admits the hated "barbarian" within her precincts.

It is needless to say that there would not be so much anxiety to establish relations between the Orient and the commercial nations of the world if it were not certain that the natural and manufactured products of China are many and valuable. Her mineral wealth is great, especially in the south and west, though the mines have as yet been very little worked. Coal, iron, lead, gold, silver, and quicksilver all await the enterprising modern worker; while Chinese porcelain, silk, tea, rice, sugar, and—last, but not least—firecrackers are well known. "China is not dead yet"; but she must arouse herself, and submit to the modern medical treatment of commercial intercourse with her kind, or she may find that

the more painful surgical operations of partition and dismemberment will be inflicted upon her by her impatient neighbors, against her will and without her consent. The outlook in the Far East is gloomy and threatening. At the end of March five navies are assembling their forces in the Yellow Sea; China's future, her very existence as an independent nation, may be at stake; and the war cloud now brooding over the western hemisphere has its counterpart on the other side of the globe.

DAINTY DESSERTS.*

Mrs. Henry Esmond.

ROYAL PUDDING—AMBROSIA—SPONGE CAKE—CHARLOTTE RUSSE—LEMON TARTS—DEEP-DISH APPLE PIE WITH HARD SAUCE.

Royal Pudding.—Line a pudding dish with a nice pie crust (as the receipt for crust has been given before, it is not necessary to repeat it); stand it in the oven and partially cook it. Remove and spread raspberry jam over the crust about 1 inch thick. Scald 1½ cups of milk; beat 3 eggs slightly and add to them 4 tablespoonfuls of sugar. Pour on the scalded milk, mix well and strain it over the jam in the pudding and grate a little nutmeg over the top. Set the baking dish in a shallow pan which has about 1 inch of hot water in it. Put in the oven and bake 20 minutes, or until the custard is set. Remove from the oven and let it get very cold. The reason for setting any custard in a pan of water in the oven is to prevent the custard from separating.

Ambrosia.—Peel 6 oranges; grate ½ of a fresh cocoanut. Cut the oranges up, removing the stringy membrane in the center. Put a layer of orange in the bottom of a glass dish, sprinkle a little sugar over; then a generous layer of cocoanut. Continue in this way until the dish is full, being careful to have a layer of cocoanut on the top. This should be prepared about one hour before serving.

Sponge Cake.—Break 5 eggs, separating the white and yolks. Beat the yolks until they are very creamy, then add to them 1 cup of fine granulated sugar and the rind and juice of either an orange or a lemon; beat hard with the egg beater, then add 1 cup of flour which has been sifted 4 times. Do not beat the flour in, but fold it in very lightly, so as to prevent the air escaping which has been beaten into the eggs and sugar. Add a pinch of salt to the whites and beat them *very* stiff—until they are quite dry. Fold them into the first mixture as quickly as you can. Pour into a pan which has quite a thick paper in the bottom. It is not necessary to butter the paper when there is no butter in the cake. The pan with a chimney in the center is better for sponge or angel cake than the ordinary loaf-cake pan, as the cake is so deep in the center that it is apt to fall, and sometimes the center will be almost raw when the rest of the cake is done. When the chimney pan is used the heat has a chance to get to the middle of the cake as well as to the bottom and sides.

Charlotte Russe.—Line a moderately deep dish with either ladyfingers or slices of sponge cake. Flavor 3 cups of sweet cream with 2 tablespoonfuls of sherry or ½ teaspoonful of vanilla. Beat until very stiff with an egg beater; sweeten with 2 tablespoonfuls of powdered sugar and beat again. Pour into the dish lined with cake and stand it away to get cold. As there is no gelatine used in making this it is very easily and quickly made.

Lemon Tarts.—The crust for these tarts is a rich, short, pie crust (the receipt has been given in a previous number). Small cake pans may be used or the crust may be cut with a cookie cutter, and the edge moistened with cold water, and a strip put on around the top. Bake in a hot oven until a very delicate brown. Put into either a bowl set in hot water or into a double boiler, 1 cup of granulated sugar, the juice of 2 lemons and the grated rind of 1 lemon, a heaping tablespoonful of butter and 3 eggs slightly beaten. Mix well, and set on the fire, where the water in the pan or under part of the double boiler will boil steadily. Stir constantly until the lemon mixture thickens—it will take about 20 minutes. When it is cool, put 1 tablespoonful into each of the tart shells. This lemon filling

* *See Editorial Notice on page 180.*

may be kept for some time in a mason jar. Large pies may be made with this same mixture; it takes just twice the receipt for a large pie and the whites of 2 eggs should be kept out for the meringue for the top. Beat stiff and add 2 teaspoonfuls of sugar; heap on the top of the pie, and set in a hot oven until a delicate brown.

Deep-Dish Apple Pie.—Pare 6 or 8 good-sized apples; cut them in quarters and put them in a pudding dish. Sprinkle ½ cup of sugar over them and put little bits of butter on top. Cover with a plate and bake in a moderate oven for 3 hours; the apples will have a red, transparent look, like quinces. Now, sprinkle cinnamon over the apples and cover with a thin pie crust. Return to the oven and bake until the crust is a delicate brown. Serve hot, with a hard sauce, which may be made in the following manner:

Sauce.—Cream 1 good-sized tablespoonful of butter; add ¾ cup of granulated sugar and 2 tablespoonfuls of cream. Beat until foamy, then add 1 tablespoonful of brandy, or 1 teaspoonful of vanilla; mix well; turn into a shallow dish and smooth over the top, and sprinkle with grated nutmeg. Let it get very cold.

THE ELECTRICAL EXHIBITION IN NEW YORK

MADISON Square Garden, in New York, is particularly well suited to exhibits of an important character, and the Electrical Exhibition, which is to be held there from the 2d to the 31st of this month, promises to be a very complete and satisfactory representation of the present state of the electrical art.

Many special features are being prepared, both in the way of exhibits of apparatus and processes, and also in exhibits of skill.

Among the former we may mention a marvelous collection of galvanoplastic work, representing the labor of many years, by Mr. H. V. Parsell, a well known banker of New York City, and an enthusiast in this line. These pieces, some being as large as 25 inches by 25 inches, are not only reproductions of famous works of art, but also reproductions of life.

Another interesting exhibit will be the mounted relics of the ill fated eagles who, while enjoying a siesta, perched on a high-potential long-distance transmission line, became involved in a heated discussion. Their remains, consisting of their beaks and talons, have been preserved by Mr. Geo. P. Low, an electrical engineer of San Francisco, and will be exhibited as an example showing the result of ignorance of the laws governing high-tension circuits.

One of the most practical exhibits, and one that will probably attract the greatest amount of attention from railroad men, will be a working model of the third-rail system, which has been operated so successfully on the New York, New Haven, and Hartford Railroad. The model consists of about a hundred feet of single and double track, of three-inch gauge, upon which a train of cars will run continuously, picking up the current from the third rail, operating the signals and switches, and working exactly as a regular train on the railroad in question.

Besides these and many other specimens of apparatus, there will take place exhibits of skill. Mr. Fred. Catlin has completed the preliminary arrangements for the telegraphic tournament, which promises some exciting times. Mr. J. H. Bunnell, whose instruments are very familiar to telegraph operators, is setting up the necessary equipment of telegraphic apparatus and auxiliary appliances. He has been instrumental in getting up an "old timer's class," in which race he himself will be an active participant.

The preceding is merely an intimation of what we may expect to find. All of the leading electrical concerns will be found to be well represented, both personally and by exhibits. The New York Electrical Society, under whose auspices the affair is to be held, is deserving of hearty thanks for its enterprise, and of congratulation for the unmistakable signs of success, which are already apparent.

NOTICES.

EDITORIAL.

A subscriber has sent us the following letter.

Editor Home Study Magazine:

I notice your foot note to the article on "Dainty Desserts" on page 129 of the current volume of your paper. I cannot refrain from expressing my surprise that any one should have found fault, in the manner you state, with this department of the magazine, and want to express my hearty indorsement of the stand you have taken in the matter. It seems to me strangely incongruous in any one to indorse a magazine because it enables its readers to get a better "living," so to speak, and then to find fault with it when it attempts to show how that "living," *when got*, may be turned to best advantage; for I feel thoroughly convinced, from considerable observation, that there is more crudity shown in spending money than in earning it; so that, taking the food department of domestic economy as the subject, no matter how well we have done in selecting the raw materials of our food, if they are spoiled in the preparing, the money is thrown away to a large extent and our capacity to earn a living reduced to the same extent.

I would suggest, as a suitable and important topic for this department of the magazine, a serial treatise, with tables, on the food values of the various materials used for food.

There is also, it seems to me, a sociological side to this matter; and that is, that it will have a tendency to unify the interests of the two sexes in the family by making them both scientific—teaching them, for instance, that the chemistry of cooking is the same as that of the factory, and, by each knowing something of the other's business in the larger sense, result in greater helpfulness and sympathy. T. S., Saginaw, E. S., Mich.

March 25, 1898.

We are glad to receive such a letter as this, and to know that our efforts are appreciated. The sentiments are an echo of our own and we certainly could not have expressed them better.

We like to feel that each of our subscribers is in sympathy with us, and that, in endeavoring to please each one, we, at any rate, satisfy the majority. Criticisms and suggestions are always a help to us.

THE *Mining Bulletin* of the Pennsylvania State College in its last number announced the review of an exceedingly valuable work for all our mine employees, in the annual report of the Bureau of State Industrial Statistics, which contains an article by the former chief, A. S. Bolles, on "The Liability of Employers to Employees." This book will be ready for distribution soon, and is of considerable importance for all who wish information on this subject.

A NEW BOOK.

LUBRICANTS, OILS, AND GREASES. THEIR COMPOSITION, USES, AND MANUFACTURE. By Iltyd I. Redwood. Published by Spon & Chamberlain, New York.

There is, perhaps, no item in a power plant in connection with which the owner is more often or more readily deceived than that of lubricants.

He generally has to take the word of the seller as to the quality and fitness of his wares. Railroads and other large users are beginning to see this, and have accordingly, established laboratories where, among other materials, their lubricants are rigorously tested.

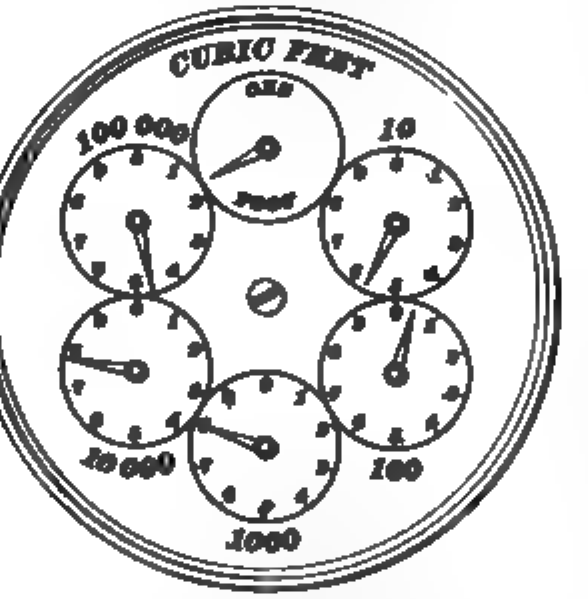
The present book, by a well known authority on the subject, shows what tests may be relied upon, and also what are in themselves insufficient. Information is also given as to testing for adulteration.

There is a chapter on the manufacture of lubricants; also a table of 50 kinds and grades of oil, showing their specific gravity, viscosity, and other properties, and in an appendix are given results of extensive experiments showing the action of various oils on the chief engineering metals.

There are, of course, plenty of honest oil dealers about, if the consumer only happens to hit on them. At the same time, it is as well to be provided with a little outside help, such as this book affords.

(157) Please explain a sure method of reading an ordinary water meter.   A. E. S., Rochester, N. Y.

ANS.—The method of reading the dials is about the same in all kinds of meters. The accompanying figure shows the ordinary arrangement of the dials. The figure to be taken is always that one which the pointer has just passed, but not the one which it is approaching. The figure which is indicated upon the dial, marked 10, is written first; that is, in the unit's place. To the left of this put down the figure



indicated upon the dial marked 100; to the left of that put down the figure indicated by the dial marked 1,000, and so on. Thus, the dials in the figure indicate 47,805 cubic feet. The small dial, marked *one foot*, indicates only fractions of a cubic foot. To find the quantity of water which has passed through the meter in a certain time, read the meter before and after the water has passed through, and subtract the first reading from the second reading.

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(158) (*a*) What is the best way to determine the latitude of any place to the nearest minute? (*b*) In a book in my possession the following example is given "On the 8th day of May, 1854, at 5 h. 33 m. 33.4 s., apparent time, the altitude of the sun's lower limit was observed to be 15° 40′ 57″, the longitude of the place being 80° 39′ 45″ W; what was the latitude? The declination of the sun, at the time of observation, is found to have been 17° 12′, and the true altitude of his center 15° 53′ 37″; hence, $P = 72° 48'$, $Z = 74° 6' 23''$, and $H = 83° 23' 21''$, where P is the polar distance, Z the zenith distance, and H the horary angle." How is the horary angle determined? (*c*) The following is a description of the horary angle "The horary angle of a body, at any instant, is an angle at the pole of the equator, contained by the meridian passing through the body and the meridian passing through the place of observation. It measures the time between the instant of observation and the instant of the body's passage over the meridian of the observer." Is the horary angle 90° minus the number of degrees which the sun makes in its approach to the meridian, or 90° minus the number of degrees since the sun was at the meridian, as the earth revolves from noon to 6 p. m.?
F. 195, Cape Town, South Africa.

ANS.—(*a*) The latitude of a place is equal to the height of the pole above the horizon of the place. Let l be the latitude, and h_1 and h_2 the greatest and the least altitudes, respectively, of a circumpolar star whose polar distance is p. Then, $l = h_1 - p$, and $l = h_2 + p$; whence, $2l = h_1 + h_2$, and $l = \frac{1}{2}(h_1 + h_2)$. The altitudes h_1 and h_2 are easily measured with an ordinary transit; they should be corrected for refraction. Corrections for refraction are given in several books of tables, and in astronomical books; also in good books on surveying. A convenient approximate formula for finding the correction for refraction is $r = 58 \cot h$, where h is the observed altitude and r is the correction for refraction, *in seconds*. This correction is to be subtracted from h. (*b*) and (*c*) The horary angle, more commonly called *hour angle*, of a heavenly body, with respect to an observer, is the angle between the meridian of the observer and the meridian passing through the body; or the angle between the planes of two great circles passing through the poles of the heavens, one through the observer and the other through the body. The hour angle is measured by the arc of the equator included between the two circles. As an *apparent* solar day is the interval between two successive passages of the sun over the same meridian, the sun describes 360° in 24 apparent hours, or 15° in 1 apparent hour. The sun's hour angle in degrees is, therefore, equal to the apparent time in hours multiplied by 15. Thus, in your example, the apparent time = 5.5598 hours, and $H = 5.5598 \times 15 = 83.3898$ degrees $= 83° 23' 21''$. The declination is taken from the "Nautical Almanac," or a similar publication. The observed altitude of the lower part of the sun's disk (15° 40′ 57″) must be corrected first for refraction. Using the formula given above, and taking the cotangent of 15° 41′, which is near enough, we get $r = 58 \times 3.562 = 206.596'' = 3' 27''$. Corrected altitude $= 15° 40' 57'' - 3' 27'' = 15° 37' 30''$. The angular semi-diameter of the sun is about 16′, which, added to the corrected altitude of the lower limit, gives 15° 53′ 30″. A more exact value is found by taking r from a table. From one before us we find that the value of r, for altitude 16°, is 3′ 20″. Using this value, instead of the calculated one, we get 15° 53′ 37″ for the true altitude of the sun's center. The zenith distance being the complement of the altitude, we have, $Z = 90° - 15° 53' 37'' = 74° 06' 23''$. The declination d = distance of sun from equator; therefore, $P = 90° - d = 90° - 17° 12' = 72° 48'$. To find latitude l we have, calling h the corrected altitude,

$$\sin h = \sin d \sin l + \cos d \cos l \cos H. \quad (1)$$

Assume an auxiliary angle x such that

$$\sin d = k \sin x, \quad (2)$$

and

$$\cos d \cos H = k \cos x, \quad (3)$$

k being a coefficient that can be easily determined,

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see advertising page IV.

but whose value is not needed. Substituting in (1), we get

$$\sin h = k(\sin l \sin x + \cos l \cos x) = k \cos(l - x);$$

whence, $$\cos(l - x) = \frac{\sin h}{k} = \frac{\sin h \sin x}{\sin d}, \quad (4)$$

from which $(l - x)$, and therefore l, can be found. Substituting known values, we have, from (2) and (3),

$$\tan x = \frac{\sin d}{\cos d \cos H} = \frac{\tan d}{\cos H} = \frac{\tan 17^\circ 12'}{\cos 83^\circ 23' 21''};$$

$$x = 69^\circ 35' 57.8''.$$

From (4), $$\cos(l - x) = \frac{\sin 15^\circ 53' 37'' \sin 69^\circ 35' 57.8''}{\sin 17^\circ 12'};$$

whence, $l - x = \pm 29^\circ 46' 21''$, and $l = 99^\circ 22' 19''$, nearly, or $39^\circ 49' 37''$, nearly. As latitude cannot be greater than 90°, we must take, for the first value, $180^\circ - l = 180^\circ - 99^\circ 22' 19'' = 80^\circ 37' 41''$. The reason why the value of $(l - x)$ has a double sign is that $\cos(-a) = \cos(+a)$. For other definitions and formulas relating to this subject, see answer to question 548 in the January, 1898, number of HOME STUDY MAGAZINE.

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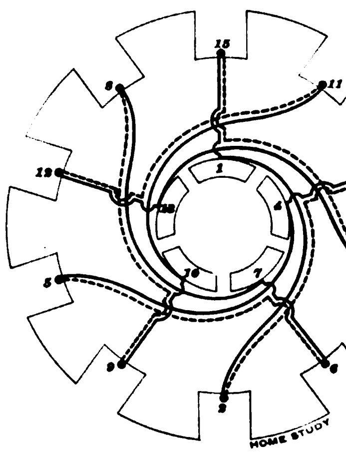
(159) I enclose a rough sketch of an armature with 10 slots. Will you kindly instruct me how to wind it? E. E. O., Waupun, Wis.

ANS.—After having figured the proper size and length of the wire to be contained in the slots *15, 11, 3, 14*, etc., the winding may be done according



to the diagram, in which *1, 4, 7, 10, 13* are the commutator bars. The full lines represent cross-connections on the commutator end of the armature, and the dotted lines represent the cross-connections at the back end of the armature. One section of the armature is wound by starting at a commutator bar, say *1*, around to *2*, to *3*, and back to *2* and *3* as many turns as required, and then to commutator bar *4*. The other sections are wound on in consecutive order, as the numerals indicate.

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(160) Will you please explain the theoretical method of determining the required heating surface of steam radiators? It is, I believe, customary in practice to allow about 1 square foot of heating surface to every 50 cubic feet of air space, with steam pressure of only a few pounds. How can I reduce the heating surface required, by increasing the steam pressure? J. D. S., Newark, N. J.

ANS.—Compute the loss of heat through the walls, windows, doors, etc., and by ventilation, if any: then provide enough radiation to counteract the total loss. To do this you may refer to the following table of coefficients, which states the loss of heat through 1 square foot of the material, per degree F. difference in temperature between the air against the inside and that against the outside surface of the material, in British thermal units per hour.

TABLE.

CHARACTER OF SURFACE.	B. T. U. Per Hour.
Window glass (single)	.776
Skylight (single)	1.118
Brick walls, 4 inches thick	.68
Brick walls, 8 inches thick	.46
Brick walls, 12 inches thick	.32
Outer doors	.42
Floors (wooden beams planked)	.083
Floors, (fireproof)	.124
Ceilings (wooden beams planked)	.104
Ceilings (fireproof)	.145
First-class wooden walls, lathed, plastered, sheathed, on studding covered with building paper and weather boarded	.1

Having determined the total loss of heat in B. T. U. per hour from the apartments to be heated, the number of square feet of radiating surface required can be computed by dividing the total heat lost per hour by the number of B. T. U. which will be emitted in one hour from the class of surface you intend to use in the radiation. This latter number can be found in the following table:

TABLE OF HEAT EMISSION.

Direct Radiators—Vertical Tube—Prime Surface.

Difference in Temperature Between the Radiating Surfaces and the Air.	Vertical Tubes Massed.		Vertical Tubes Single Row.	
	40 Inches High. B. T. U.	24 Inches High. B. T. U.	40 Inches High. B. T. U.	24 Inches High. B. T. U.
100	1.40	1.74	1.65	2.27
120	1.52	1.82	1.73	2.38
140	1.59	1.90	1.81	2.48
160	1.66	1.98	1.88	2.59
180	1.73	2.06	1.96	2.70
200	1.80	2.14	2.03	2.80
220	1.86	2.22	2.11	2.90
240	1.93	2.31	2.19	3.01

The B. T. U. given in this table is the rate of heat tansmission for each degree difference in temperature.

EXAMPLE.—Given a rectangular room 50 feet long, 30 feet wide, with 10 feet ceiling. All four walls are exposed to the weather and are of brick 8 inches thick. The floor consists of wooden beams planked, and about one-half of it is exposed to the cold. The ceiling consists of wooden beams planked and exposed to a cold attic. There are 16 single-glass windows in the walls, each window containing 15 square feet of glass surface. How many square feet of single-row prime surface 24 inches high will be required to heat the room to 70° during zero weather, using steam at atmospheric pressure? Allow 20% extra radiation for air leakage.

SOLUTION.—Heat losses through:

Windows $= 16 \times 15 \times .776 \times 70 = 13{,}036.8$ B. T. U.

Walls $= [10(50 + 50 + 30 + 30) - 16 \times 15] \times .46 \times 70 = 43{,}792$ B. T. U.

Floor $= \frac{50 \times 30}{2} \times .083 \times 70 = 4{,}357.50$ B. T. U.

Ceiling $= 50 \times 30 \times .104 \times 70 = 10{,}920.$ B. T. U.

Total loss per hour .... $= 72{,}106.30$ B. T. U.

Referring now to the second table, $212 - 70 = 142^\circ$

being the difference between the temperature of the steam and the air, it follows that the amount of radiation required is $\frac{72106.3}{142 \times 2.5} = 203$ sq. ft., nearly. But to this must be added 20%, as stated, which gives 244 sq. ft. as the total amount of radiation required. The above process holds good for all temperatures and pressures, and is so broad gauged that it takes in nearly all conditions, provided the proper coefficients for both the cooling and the heating surfaces can be obtained.

* * *

(161) Fig 1 is a sketch of an eccentric bolt head, which is supposed to have been turned off with the eccentric. I wish to know how to lay out a tin template which, when rolled up and slipped over the cylindrical head, as shown in Fig. 2, can be used to mark off the chamfered head from.

H. M. B., San Francisco, Cal.

ANS.—Draw a plan and elevation of the chamfered head, as on Fig. 3; with the dividers, divide one-half of the circle into 10 equal parts, marking them

FIG. 1. FIG 2.

FIG. 3. FIG. 4.

0, 1, 2, 3, to *10*. Project these points down to the elevation as shown. Then, as in Fig. 4, draw a horizontal line of indefinite length, and lay off upon it a length equal to the circumference of the bolt head, or $2\frac{5}{8}'' \times 3.1416 = 8.246$; $8\frac{1}{4}$ is near enough. Divide this length into 20 equal parts, numbering them as shown. Erect a perpendicular from each point, and make its length equal to the length of the corresponding perpendicular in Fig. 3. Through the points thus located draw the curve, and the figure *0′ 0′ 10″ 0 0′* is the required template.

* * *

(162) I would like to be informed as to a remedy for troublesome echoes in a large second-floor room that is to be used for social gatherings. The room, which is 72 ft. × 18 ft. 6 in. × 19 ft. 11 in. high, is plastered smooth white, has nothing in it at present but the chimney, gas fixtures, and steam radiators; the wood floor is uncarpeted. The ordinary furniture of such a meeting place does not fill much as to elevation from floor level, and I fear will not be enough to prevent the echo. I have an undefined recollection that wires stretched somewhere in the room would neutralize the echo. Can you recommend a simple and positive remedy?

F. A. S., Washington, D. C.

ANS.—Rectangular rooms with plain walls are very likely to be productive of bad echoes, especially when the ceiling is lofty. It is a very difficult matter to give specific advice as to what methods are applicable to any particular case, without an inspection of the room and an experiment with its echoes. The most serious echoes being usually reflected from the angles of the room, we would suggest that the angles between the side walls and ceiling be broken by the insertion of large plaster coves, while the angles between the side and end walls may be similarly treated, or the walls may be hung with heavy draperies, which will absorb the sound, but not reflect it. The rear wall or else the one in front of the speaker should be broken up by means of piers or niches, or even by window or door openings, and the ceiling should have girders or ribs extending across it to prevent the reflection of sound from it to the side walls. When the hall is tested for echoes, it should be filled with people to the number of at least two-thirds of its full capacity, as in some cases a room which is acoustically perfect when occupied, has prominent acoustic defects when nearly empty.

* * *

(163) (*a*) If natural gas is being discharged from a pipe, and a check-valve at the discharge end is suddenly closed, will there be any shock due to the sudden stopping of the gas, or will the gas *cushion* itself? (*b*) Can you tell me of some good books on the science of gases, especially natural gas? I want a book that treats of heat as produced by gas for furnace use—the properties of air—the results of mixing air with furnace gas, and so on. C. D. E.

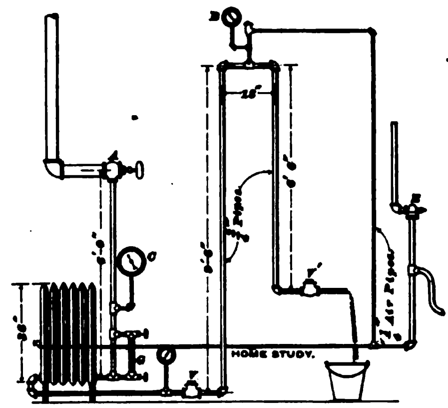
ANS.—(*a*) There will be no perceptible shock, because of the elasticity of the gas, which produces a cushion, as you suggest. (*b*) "Petroleum and Its Products and Natural Gas," by Wm. T. Brannt, price $7.50.

* * *

(164) In answer to question 410 in the October, 1897, HOME STUDY MAGAZINE, you give sketch of radiator and connections. (*a*) Is it necessary that ejectors be placed in air pipes? If so, why? (*b*) Could the loop be constructed to work without it? (*c*) Why is check-valve 1″ placed in horizontal discharge pipe? S. A. F., Cincinnati, O.

ANS. (*a*) Since the pressure of the steam at the compound gauge *C*, in the sketch referred to, and reproduced here, is equal to that of the atmosphere, it follows that the air in the radiator cannot flow to the outer atmosphere without the assistance of some apparatus, such as a pump or an ejector, like that used by W. H. S. Neither can the loop be conveniently charged with steam, unless an ejecting apparatus is employed to remove the air. If the air is not removed by force from the steam loop, the

loop would not start, and the radiator, consequently, would become flooded. (*b*) The loop can be made to operate without the assistance of the ejector, by simply filling it with steam and then shutting off the steam supply. When the steam condenses in the loop, the check-valve V' will prevent air from flowing back to the loop, and water of condensation from the radiator will consequently flow up the long leg of the loop in the form of plugs, as it were, with considerable steam space between them, unless, of



course, the radiator is flooded before you try to start the loop. In such a case the loop will not work unless the pressure at C rises sufficiently high to compensate for the difference in weight of the water in the legs of the loop. In the construction shown by W. H. S., and according to his description of the existing conditions, it would be too risky to attempt to drain water from the radiator without the periodical assistance of an ejector or an air pump. (*c*) This check-valve does not perform any very important part in the operation of the apparatus, and it appears to us that the check might be taken out without affecting the loop.

***

(165) Referring to answer to question 20 in the February number of HOME STUDY MAGAZINE, there is evidently a mistake somewhere. I find that the lengths, as you have calculated them, do not agree with those found by making a lay-out.

J. B. C., Manchester, Ohio.

ANS.—The question referred to may be stated as follows: The sides of a triangle are $BC = 400$, $CA = 600$, and $AB = 800$. On the side BC, an arc of a circle is described containing an angle $l = 22° 30'$; on the side AC, an arc is described containing an angle $m = 33° 45'$. If these circles intersect in the point P, find AP and BP.

There are four possible positions of the point P, because we can describe two arcs having their centers on opposite sides of BC, and two having their centers on opposite sides of AC—as shown in Figs. 1, 2, 3, and 4. By a mistake of sign in our February number, the solution which belongs to Fig. 1 was applied to Fig. 2. The solution there given is correct for Fig. 1. To apply the formula for AP to Fig. 2, it is only necessary to change l into $(180° - l)$ and m into $(180° - m)$, or to change $\cot l$ into $-\cot l$ and $\cot m$ into $-\cot m$; for Fig. 3 the sign of $\cot l$ must be changed in the formula; for Fig. 4 the sign of $\cot m$ is changed.

The corresponding formula for BP is

$$BP = \frac{AB(\cot B + \cot m)}{\sin l\sqrt{(\cot A + \cot B + \cot l + \cot m)^2 + (\cot A \cot m - \cot B \cot l)^2}}$$

This formula applies to Fig 1, and is made applicable to the other three cases by changing the signs of $\cot l$ and $\cot m$. Thus, we get,

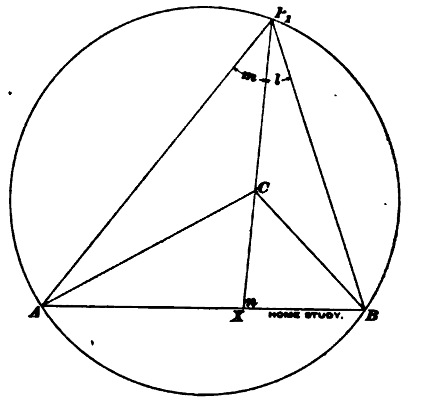


FIG. 1.

$AP_1 = 910.3$, $AP_2 = 710.2$, $AP_3 = 164.3$, $AP_4 = 981.2$.
$BP_1 = 764.9$, $BP_2 = 934.3$, $BP_3 = 960.5$, $BP_4 = 185.5$.

To show how each case can be solved independently, we give another method of finding AP_2 in Fig. 2.

In the triangle ABC,

$$\cos \tfrac{1}{2} A = \sqrt{\frac{s(s-a)}{bc}};$$

therefore, $A = 28° 57' 18''$, angle BAE = angle $BP_2E = 22° 30'$, and angle ABE = angle AP_2E =

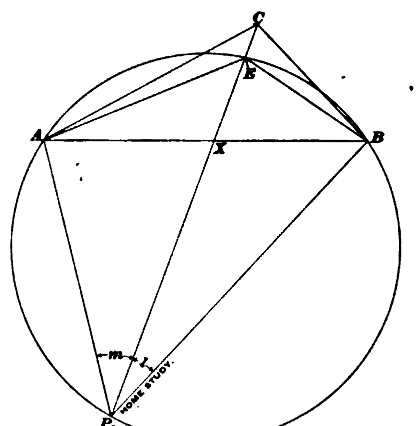


FIG. 2.

$33° 45'$; for angles inscribed in the same circular segment are equal. Hence, also, angle $AEB = 123° 45'$.

In the triangle AEB,

$$\frac{AE}{AB} = \frac{\sin ABE}{\sin AEB} = \frac{\sin 33° 45'}{\sin 123° 45'},$$

which gives $AE = 534.54$.

Angle EAC = angle BAC − angle BAE = $6° 27' 18''$. In the triangle ACE,

$$\frac{AC + AE}{AC - AE} = \frac{\tan \frac{1}{2}(AEC + ACE)}{\tan \frac{1}{2}(AEC - ACE)},$$

or, $\frac{600 + 584.54}{600 - 584.54} = \frac{\tan \frac{1}{2}(180^\circ - 6^\circ\ 27'\ 18'')}{\tan \frac{1}{2}(A\,E\,C - A\,C\,E)} =$

$$\frac{\tan \frac{1}{2}(86^\circ\ 46'\ 21'')}{\tan \frac{1}{2}(A\,E\,C - A\,C\,E)}.$$

Whence, $\frac{1}{2}(A\,E\,C - A\,C\,E) = 45^\circ\ 39'\ 18''$.

$\frac{1}{2}(A\,E\,C + A\,C\,E) - \frac{1}{2}(A\,E\,C - A\,C\,E) = A\,C\,E = 41^\circ\ 7'\ 3''$.

Therefore, $A\,C\,P_3 = A\,C\,E = 41^\circ\ 7'\ 3''$.

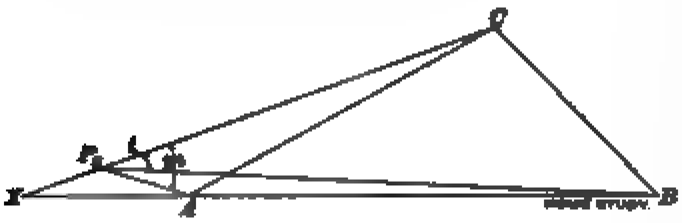


FIG. 3.

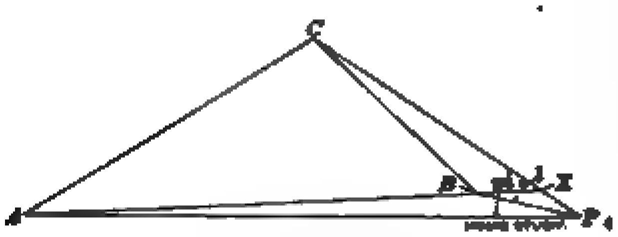


FIG. 4.

In the triangle $A\,C\,P_3$,

$$\frac{A\,P_3}{A\,C} = \frac{\sin A\,C\,P_3}{\sin A\,P_3\,C}$$

or, $$\frac{A\,P_3}{600} = \frac{\sin 41^\circ\ 7'\ 3''}{\sin 33^\circ\ 45'}.$$

Therefore, $A\,P_3 = 710.2$.

* * *

(166) The enclosed are drawings of a steam-shovel dipper that I have had to design to contain 1¾ yards stroke measure. Without being very precise in my calculations; I estimated the contents at 50.6 cubic feet; this I concluded would be surplus enough to make up for the teeth and mouthpiece, which are inside the shell. Now, the foreman blacksmith, who is quite an expert on large dippers, says it will not hold 1¾ yards. Which of us is right?

D. C. W., Toledo, Ohio.

ANS.—Allowing for the teeth, we figure the contents to be a trifle over 48 cubic feet; that is, somewhat in excess of that required.

* * *

(167) I have read with much interest your article on "Incrustation in Steam Boilers," and would like to ask a question: I heat my stores and flats by steam heat; I have been using artesian-well water for everything, and find it eats all kettles and fire backs and everything else. Now, instead of going to so much trouble to purify water for the boilers, why not use rain water as it comes off the roof of the building?

W. E., Oak Park, Ill.

ANS.—If your buildings covered an area of 60 ft. × 30 ft. you would get, with a yearly rainfall of 40 inches, about 90 gallons of water per day, if you managed to catch 75 per cent. of the fall. If you think that would be enough for your purpose you might try it. Rain water, however, is by no means as free from impurities as a good many people imagine. It picks up all kinds of impurities from the air while falling. In manufacturing districts the chemical impurities derived from the smoke are considerable; and other foreign substances are gathered from roofs of buildings. Of course, the larger mechanical impurities, such as twigs, leaves etc., can be kept back by a strainer. However, rain water contains much less solid matter than ordinary well water, and, if you can obtain it in sufficient quantities, should prove beneficial.

(168)—(*a*) Can aluminum be soldered? If so, how? (*b*) Can metal be burnt? (*c*) What are motor brushes made of? (*d*) I have a "Dollar" motor which is run by battery pads, how can they be made?

E. W. W., DeLand, Fla.

ANS.—(*a*) You will find a receipt for aluminum solder in answer to question 137 in HOME STUDY MAGAZINE for April, 1898. (*b*) Yes; not in the sense that wood burns, though. Iron, for instance, burns when in the presence of moisture, the iron combining with oxygen to form oxide of iron, commonly called *rust*. At high temperatures, metal burns more rapidly but in much the same way. (*c*) Carbon is the most suitable material. (*d*) The battery you refer to is probably a modification of the one described in answer to question 295, HOME STUDY MAGAZINE for August, 1897

* * *

(169) (*a*) In Fig 1 are shown two arrangements of pulleys and belting. In one, two 24-inch pulleys are connected by a belt, and in the other, two 30-inch pulleys are similarly connected. The two belts are exactly alike in width and thickness, and the tensions in them are equal. Which of the arrangements will transmit the greater power? In other words, which belt will slip first, and why? (*b*) Fig. 2 represents a water-jacket. Cold water, at a pressure of about 17 pounds per square inch, enters at *A*, and

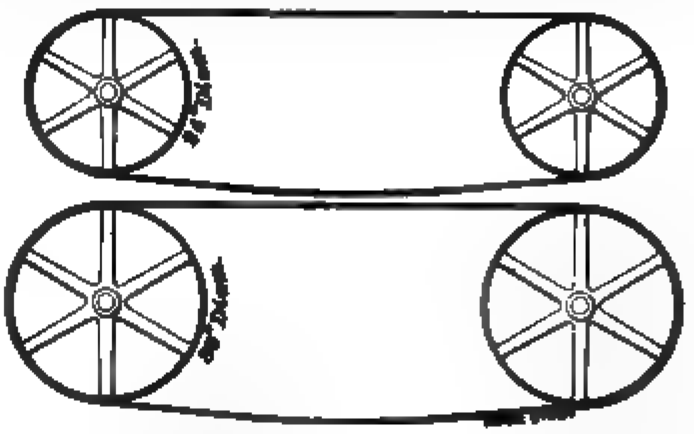


FIG. 1.

B is the outlet. Will the cold water that enters at *A* be distributed equally in all parts of the jacket, especially at *C* and *D*? C. T., Dayton, Nevada.

ANS. (*a*) For moderate speeds—for which the effect of the centrifugal force, which always prevents a belt from hugging its pulley to the full extent of its tension, is but small—the larger pulleys will, of course, transmit the greater amount of power: but as the centrifugal force increases with the square of the velocity, there is necessarily a speed for which the two arrangements will transmit just the same power, and above which the smaller pulleys will transmit the *greater* amount. For the pulleys in question, with properly tightened, good, laced belts, the speed of equal power will be about 67 revolutions per minute. (*b*) The strongest current through the jacket will no doubt be nearly on a diagonal line between the two pipes, so that the hot water in the corners *C* and *D* will not be replaced by the cold water so rapidly as will the main body of the water.

FIG. 2.

* * *

(170) Kindly develop the plate as per Fig. 1 enclosed. W. K. C., Youngstown, O.

ANS.—First draw the two views *A* and *B* from the

given dimensions, as shown in the figure. Divide the inner and outer ellipses into a number of equal parts. In the figure each half ellipse is divided into 12 parts, the points of division being denoted by a, b, c, etc. and $1, 2, 3$, etc. These points are now projected into the elevation B, giving the points a', b', c', etc. on the top

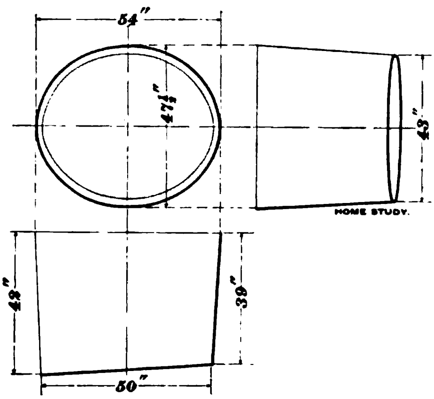


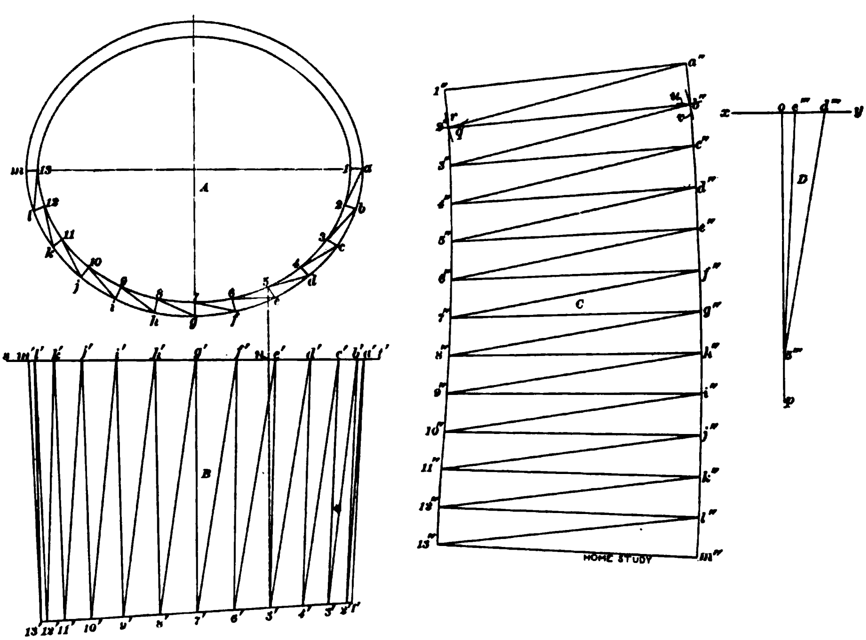
FIG. 1.

of the shape, and $1', 2', 3'$, etc. on the bottom. Next, the surface is covered by a network of triangles, which are obtained by joining points 1 and a, $1'$ and a'; 2 and b, $2'$ and b'; 3 and c, $3'$ and c'; and so on; also points 2 and a, $2'$ and a'; 3 and b, $3'$ and b', etc. The problem now is to lay out these triangles on a flat surface and thus obtain the desired development. In order to do this the actual lengths of the lines of the triangles must be found. As shown in Fig. D, draw two lines $o\,p$ and $x\,y$ at right angles to each other. Suppose, now, we wish to find the length of the sides $5'\,c'$ and $5'\,d'$ of the triangle $5'\,c'\,d'$; a perpendicular is drawn through $5'$ to $s\,t$, cutting $s\,t$ in n; from o, Fig. D, $o\,5'''$ is laid off equal to $5'\,n$, $o\,c'''$ equal to $5\,c$ and $o\,d'''$ equal to $5\,d$; then $5'''\,c'''$ and $5'''\,d'''$ are the actual lengths of the sides of the triangle as they will appear in the development. In this way the lengths of all the other lines are to be found. Now, in Fig. C draw the line $1''\,a''$ equal in length to $1'\,a'$; find the actual length of line $a'\,2'$ as shown in Fig. D; with this length as a radius and a'' as a center, describe the short arc r; with $1''$ as a center and the distance 1-2, Fig. A as a radius, describe the arc q intersecting arc r, and mark the point of intersection $2''$; then triangle $a''\,1''\,2''$ is the development of the first triangle. Now take the distance $a\,b$, Fig A, as a radius and a'' as a center and describe the arc u; take the actual length of $2'\,b'$ as a radius and with center $2''$ describe the arc v; the intersection of these arcs in the point b'' and triangle $a''\,2''\,b''$ is a second developed triangle. The remainder of the plate is developed in a similar manner. The distances $a''\,b''$, $b''\,c''$, etc., are equal, respectively, to $a\,b$, $b\,c$, etc., and the distances $1''\,2''$, $2''\,3''$, etc., are equal to $1\,2$, $2\,3$, etc. Fig. C shows the development of one-half of the plate; the other half has, of course, the same form.

***

(171) (*a*) Is it your opinion that electric machinery will ever entirely take the place of the steam engine? (*b*) Can electric machinery be run without a steam engine or an engine of some kind? (*c*) Is there any acid in common beef tallow that would injure the parts of a steam engine? B. C., Cleves, Ohio.

ANS.—(*a*) Electricity is not a source of power. It is merely a means of *transmitting* power, and can never take the place of the steam engine. (*b*) No. Many people imagine that the electric motor which is used so much now for driving machinery is ousting the steam engine from the market. This is not so. The machinery is indirectly driven by an engine, but the engine is probably a large one and



may be miles away from the machine. Electricity is simply a very efficient means of transmitting the power of the engine to the machinery through dynamo and motor. (*c*) Fresh beef tallow is neutral, that is, neither acid nor alkaline; but in a rancid state, produced by decomposition through hot and moist air, it has an acid reaction, and in this state is undoubtedly injurious to iron.

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(172) I enclose a sketch showing the general arrangement of some furnaces for heating steel angle bars which have to be bent to different shapes (sizes 3" x 6" and 3" x 3"). I am told that it requires 20 minutes' heating in these furnaces before the steel can be bent. (*a*) Can you give me some idea of how the smoke can be conducted to the chimney in order that the heat from the fireboxes may be used most advantageously? (*b*) Please give formula for obtaining the full consumption per hour, for operating these furnaces, both singly and together.

J. M. C., Philadelphia, Pa.

Ans.—(*a*) The sketch does not show the construction of the interior of the furnaces very clearly; for example, it is uncertain whether there are three single furnaces, one with one firebox, one with four fireboxes and one with two fireboxes; or whether there are three sets of furnaces, each firebox serving to heat a separate furnace. Whichever is meant, however, the flues should be so arranged as to cause the flame, in its passage from the firebox, to be held in close contact with the bars as long as possible before leaving the furnace, so as to give up its heat to the steel as thoroughly as possible. It is also important that the flame be evenly distributed through the furnace, so as to heat the bars evenly. If, as appears most probable from your sketch, there are three separate furnaces with one, four, and two fireboxes, respectively, and each furnace consists of a long chamber with a door at the end, the following plan would probably give satisfactory results: Run a branch flue from the back at each end of the furnace having but one firebox, as shown in the figure. In the other furnaces run a branch flue from the back of the furnace at each end, and also one from the middle of the space between each of the fireboxes. Each branch flue should be provided with a damper for regulating the flow of the gases through it; this will make it possible to control the heat in the different parts of the furnace so as to heat the bars evenly. (*b*) It is impossible to give a formula for the amount of fuel that will be required that will have any practical value.

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(173) (*a*) Where are the headquarters of the American Society of Civil Engineers? (*b*) What are the conditions of membership? (*c*) Compare by means of an illustration the Fahrenheit, Centigrade, and Reaumur temperature scales, giving rules by which any one of them can be converted into either of the others. (*d*) Who are the American agents of the London *Engineer?* (*e*) I have a fair knowledge of algebra and trigonometry, and I wish now to study the following subjects: analytical geometry, calculus, chemistry, physics, mechanics, geology, botany, astronomy, descriptive geometry, and projection drawing. Can you tell me of good books on all these subjects? (*f*) I want a good general all-round engineer's pocketbook on civil engineering, and also one on mechanical engineering.

H. S. B., Ada, Ohio.

Ans.—(*a*) and (*b*) You may obtain all information with regard to the matter by writing to Mr. C. W Hunt, 220 W. Fifty-Seventh street, New York, who is the secretary of the society. (*c*) Between the freezing and the boiling point the Centigrade thermometer is divided into 100 degrees (from 0° to 100°), the Reaumur into 80 degrees (from 0° to 80°), and the Fahrenheit into 180 degrees (from 32° to 212°). Therefore, 1° C. $= \left(\frac{80}{100}\right)^\circ$ R. $= \left(\frac{180}{100}\right)^\circ$ F., or 1° C. $= \left(\frac{4}{5}\right)^\circ$ R. $= \left(\frac{9}{5}\right)^\circ$ F. Similarly, 1° R. $= \left(\frac{5}{4}\right)^\circ$ C. $= \left(\frac{9}{4}\right)^\circ$ F., and 1° F. $= \left(\frac{5}{9}\right)^\circ$ C. $= \left(\frac{4}{9}\right)^\circ$ R. Let C, R, and F be the corresponding *readings* of the three thermometers for the same temperature. Then, to transform them into one another, we have, $C = \frac{5}{4}R = \frac{5}{9}(F-32)$; $R = \frac{4}{5}C = \frac{4}{9}(F-32)$; $F = \frac{9}{5}C + 32 = \frac{9}{4}R + 32$. For example, to find how many degrees Centigrade and Reaumur are equivalent to 98° F. (blood heat), we have, $C = \frac{5}{9}(98-32) = 36.7°$ C., and $R = \frac{4}{9}(98-32) = 29.3°$ R. An interesting application is to find the temperature at which the Fahrenheit and the Centigrade thermometers have the same reading. Making $C = F$, we get $C = \frac{5}{9}(C-32)$, whence $C = F = -40°$. (*d*) The International News Company, 39 and 41 Chambers street, New York City. (*e*) Wentworth's "Analytic Geometry" ($1.25), Osborne's "Differential and Integral Calculus" ($2.00), Avery's "Elements of Natural Philosophy" ($1.15), Ganot's "Physics" ($5.00), Richter's "Inorganic Chemistry" ($1.75), Le Conte's "Compend of Geology" (about $1.75), Balfour's "Manual of Botany" ($3.00), Parkinson's "Elementary Mechanics" ($2.25), Woolf's "Descriptive Geometry" ($3.00), Young's "Elements of Astronomy" ($1.40), and "General Astronomy" ($2.25). (*f*) Trautwine's "Civil Engineer's Pocketbook" ($5.00), and Kent's "Mechanical Engineer's Pocketbook" ($5.00). All these books may be ordered from the Technical Supply Co., Scranton, Pa., either directly or through the editor of Home Study Magazine.

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(174) I am building an incubator, but do not know how to regulate the heat. Kindly suggest a practical method of making a heat regulator. My idea is to use hot water in some way.

W. E. Y., Baltimore, Md.

Ans.—The most common method of regulating the temperature of an incubator is to arrange a float in the expansion pipe or the hot-water heating tank. As the water becomes heated, it expands, and the water line consequently rises in the expansion pipe or tank. This raises the float, and its movement is communicated to a valve or other attachment which controls the amount of gas or oil to be consumed. The best plan, however, is to make a thermostat regulator

placing it inside the incubator, and arranging it in such a manner that a slight movement of the expanding bar or diaphragm will operate the gas valve. Since the principal requirement of an incubator is the maintenance of a uniform temperature inside, it follows that the latter plan is better than the former, because the flame which heats the incubator is controlled by changes in temperature of the inside air. Fig. 1 shows how a simple heating system may be

FIG. 2. FIG. 1.

arranged for a small incubator. A copper heater a connects with a heating coil b, by means of a flow pipe c and a return pipe d. The return end of the coil is the highest point, and an expansion tank e is attached to this point to allow air to escape, and the water to expand and contract according to its temperature. A Bunsen burner is set under the heater, and its gas-supply pipe has a controlling valve or cock at f. This valve has a lever handle connected by a rod to a flexible diaphragm in a thermostat which is placed inside the incubator; this thermostat is shown in section at g, Fig. 2. A small quantity of any liquid which boils at a temperature lower than 70° F. is poured into the thermostat, and a light spiral spring around the rod h tends to press the corrugated diaphragm inward. When the temperature inside the incubator increases, the pressure of the vapor in the thermostat also increases, until it is high enough to close the valve. When the temperature falls again, the spring opens the valve. The pressure of the spring can be adjusted by a locknut, so that the thermostat will control the gas-supply valve at any temperature desired. If this apparatus is properly made and adjusted, the variation of temperature in the incubator need not exceed 3 or 4 degrees. A separate stopcock should be used to entirely shut off the gas when desired.

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(175) (*a*) What is the size of a tetrahedron that can be enclosed in a sphere 2 feet in diameter, and how is it evolved? (*b*) What is the difference between an injector and an inspirator? (*c*) Where can I get binders for HOME STUDY MAGAZINE? (*d*) How are permanent magnets made? (*e*) Where can I get a good camera lens and photographic supplies? (*f*) What is, and where can I get, a good book on photography? C. W. C., Lowell, O.

ANS.—(*a*) From the vertex a of the tetrahedron the perpendicular $a\,c$ is dropped to the opposite face. The center of the circumscribing sphere lies on this perpendicular $\frac{3}{4}$ of the distance $a\,c$ from a. That is, letting r = the radius of the sphere, $r = \frac{3}{4}\,a\,c$, or $a\,c = \frac{4}{3}\,r$. The point c lies on a perpendicular $b\,d$ from b to the edge $e\,f$, and is so situated that $b\,c = \frac{2}{3}\,b\,d$. Denote one of the equal edges $a\,b$, $a\,e$, etc. by x. From the right-angled triangle $b\,d\,c$,

$$b\,d = \sqrt{\overline{b\,c}^2 - \overline{d\,c}^2} = \sqrt{x^2 - \left(\frac{1}{2}x\right)^2} = \frac{x}{2}\sqrt{3}.$$

$$b\,c = \frac{2}{3}\,b\,d = \frac{2}{3} \times \frac{x}{2}\sqrt{3} = \frac{x}{3}\sqrt{3}.$$

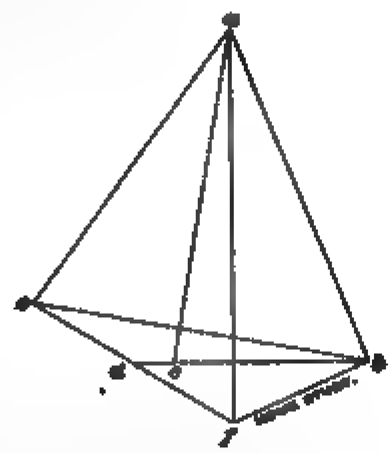
From the right-angled triangle $a\,b\,c$,

$$a\,b = x = \sqrt{\overline{a\,c}^2 + \overline{b\,c}^2} = \sqrt{\left(\frac{4}{3}\,r\right)^2 + \left(\frac{x}{3}\sqrt{3}\right)^2},$$

or $x^2 = \frac{16}{9}\,r^2 + \frac{x^2}{3}$; $\frac{2}{3}\,x^2 = \frac{16}{9}\,r^2$; $x^2 = \frac{8}{3}\,r^2$; $x = \frac{2r}{3}\sqrt{6}$.

In the present case, the radius r is 1 foot; hence, the side of the tetrahedron is $\frac{2}{3}\sqrt{6} = 1.633$ feet. The altitude $a\,c$ is $\frac{4}{3}$ ft. $= 1.333$ ft. The area of the face $b\,e\,f$ is $\frac{b\,d \times e\,f}{2} = \frac{x^2}{4}\sqrt{3} = \frac{2r^2}{3}\sqrt{3} = \frac{2}{3}\sqrt{3}$ square ft. The volume of the tetrahedron $= \frac{1}{3} \times$ base $b\,e\,f \times$ altitude $a\,c = \frac{1}{3} \times \frac{2}{3}\sqrt{3} \times \frac{4}{3} = \frac{8}{27}\sqrt{3} = .5132$ cu. ft.

(*b*) The term inspirator is sometimes applied to a double injector in which one tube lifts the water and delivers it to the second, which forces it into the boiler. (*c*) The Technical Supply Company, Scranton, Pa. (*d*) The opposite poles of two magnets are placed in the middle of the bar to be magnetized, and the two magnets are then drawn simultaneously towards the ends of the bar. This operation is repeated several times. (*e*) E. & H. T. Anthony, New York, or Jas. T. Smith & Co., Chicago. (*f*) Stepping Stones in Photography, Edward W. Newcomb, 20 E. 17th Street, New York; First Step in Photography, Dundas Dodd, Tribune Building, Chicago.



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(176) How many balls each 1 inch in diameter can be placed in a box 12″ x 12″ x 12″ (capacity 1,728 cubic inches)? C. G. F., Montreal, Canada.

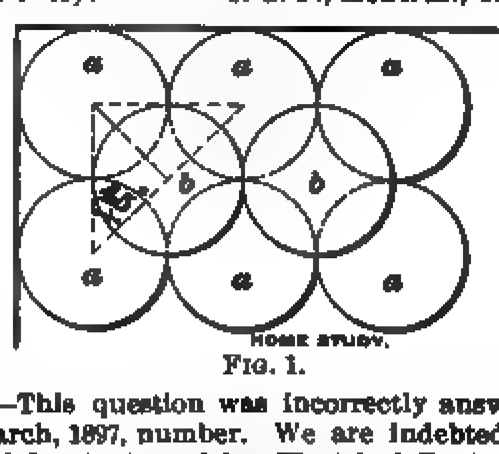


FIG. 1.

ANS.—This question was incorrectly answered in our March, 1897, number. We are indebted to Mr. Winford Lewis, Consulting Electrical Engineer, 3418 Chestnut Street, Philadelphia, Pa., for drawing our attention to the mistake and for the following correct solution. Suppose the first two layers to be arranged as shown in Fig. 1. Then there are 144 in the first layer, and 121 in the second. To find the vertical distance between the planes containing the centers of these layers, draw a plane through the centers of two balls in the first layer, and of one ball in the

second, as shown in Fig. 2. The required vertical distance is BX. From the first layer we find $A_1 A_2 = \sqrt{2}$, and we have $A_1 B = A_2 B = 1$. Therefore, $A_1 B A_2$ is an isosceles right triangle.

Therefore, $BX = \frac{1}{2}\sqrt{2} > .7071 < .7072.$

($>$ means *is greater than;* $<$ means *is less than.*) There are 14 spaces between 15 layers, hence the vertical distance from center of first layer to center of fifteenth equals

$$14 \times BX > 9.8994 < 9.9008.$$

The distance from the bottom of the box to the center of first layer is $\frac{1}{2}$ inch and the distance from the center of fifteenth layer to the top of the same layer is $\frac{1}{2}$ inch. Hence, the height of fifteen layers $> 10.8994 < 10.9008$. We can now insert a sixteenth layer, containing 144 balls, and the total height of

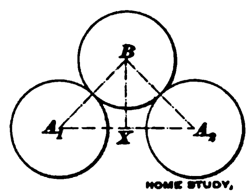


FIG. 2.

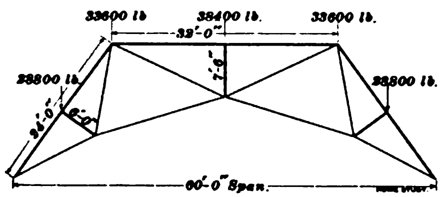
the sixteen layers will be $> 11.8994 < 11.9008$. So the box can contain 9 layers of 144 balls and 7 layers of 121 balls, or a total of 2,143 balls.

* * *

(177) I enclose a sketch of roof truss. The compression members are to be of wood; the tension members of iron; it is to be loaded approximately as shown. (*a*) How can I find graphically the stresses in the various members, caused by load and wind pressure? (*b*) What should be the dimensions of the various members of the truss?

W. B. G., Ottawa, Ont.

ANS.—(*a*) By computing the reactions and drawing the stress diagram for each condition of loading or wind pressure assumed. You will find the method of constructing the stress diagrams for roof trusses clearly explained in a book entitled "Graphical Analysis of Roof Trusses," by Prof. C. E. Greene, for sale by the Technical Supply Company, Scranton, Pa.; price, $1.25. (*b*) Having determined the max-



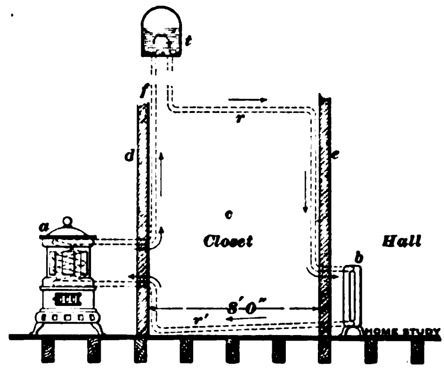
imum stresses in the various members, the sectional area required for each member, in square inches, may be determined by dividing its maximum stress by the permissible working stress per square inch, which will depend upon the material used, and in case of compression members, somewhat upon the relative length and cross-sectional dimensions.

* * *

(178) I enclose a sectional elevation of a dwelling, the hall of which I desire to heat with a hot-water radiator *b*, from a hard-coal burner *a*, making the connections through the partitions *d* and *e*, and closet *c*, a total distance of about 10 feet. The coil of pipe in the stove will be about 2′ 6″ from the floor. (*a*) Please show how the connections should be made in order that the arrangement will work properly. (*b*) How much pipe should be used in the coil, and what should be the position of the coil in relation to the coal in the firepot? (*c*) What size of pipe should be used? (*d*) What size of radiator should be used? (*e*) What should be the position of the supply tank? (*f*) What would be the heating capacity of such a system?

J. E. L., Richwood, Ohio.

ANS.—(*a*) We show the arrangement of the piping by dotted lines in your sketch. The flow pipe *f* connects a pipe coil inside the firebox of the stove with an expansion tank *t*, and a return pipe *r* connects the expansion tank to the top tapping of the radiator. Another return pipe *r′* connects the lower tapping of the radiator with the heating coil. Circulation proceeds in the direction of the arrows. (*b*) The size of the coil will depend upon size of radiator, and the height to which you can run the flow and return pipes above the heater. About 1 sq. ft. of coil surface



to every 7 or 8 sq. ft. of radiation would probably be ample. The location of the coil depends chiefly upon the internal construction of the heater. Place it in the hottest part without obstructing the firepot. (*c*) This, also, will depend upon the amount of radiation in the hall. Probably $1\frac{1}{4}$-inch pipe is best adapted for this particular work. (*d*) We cannot tell you what size of radiator to use, as you do not give us any information regarding the size and kind of hall to be heated. (*e*) As high as you possibly can get it. In the attic, if convenient. (*f*) This depends upon so many conditions that we cannot pretend to give any answer.

* * *

(179) (*a*) If 78 numbered slips are placed into a box and 12 of them are drawn at random, what chance have I of guessing 3 of the 12 correctly, one guess only of the 3 numbers being permitted? Give the solution. (*b*) How do crayon artists secure enlarged outlines of photographs? (*c*) What is mineral wool composed of?

A. B. C., Quincy, Ill.

ANS.—(*a*) If an event can happen in m ways and fail in n ways, each of these ways being equally likely to happen, and if one of them must happen, and only one can happen, the mathematical probability, or chance, of it happening is $\frac{m}{m+n}$. Thus, the probability is expressed by a fraction whose numerator is the number of favorable ways, and whose denominator is the whole number of ways. In this example $m + n =$ number of ways of drawing 12 slips from a box containing 78 slips. Hence, $m + n =$

$$\frac{78 \times 77 \times 76 \times 75 \times 74 \times 73 \times 72 \times 71 \times 70 \times 69 \times 68 \times 67}{1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9 \times 10 \times 11 \times 12}$$

When the guess has been made, the number of ways in which those three slips can have been included among the 12 that have been drawn is the same as the number of ways of drawing 9 slips from a box containing 75 slips. Therefore, $m =$

$$\frac{75 \times 74 \times 73 \times 72 \times 71 \times 70 \times 69 \times 68 \times 67}{1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9}.$$

Hence, the probability $=$

$$\frac{m}{m+n} = \frac{10}{3{,}458}.$$

(*b*) Some crayon artists use a pantograph for enlarging portraits, but the method of working upon solar prints is more commonly used. A solar print is an enlarged photograph on crayon paper. (*c*) Mineral wool is composed of slag which is blown into very fine threads while in a molten state.

* * *

(180) Kindly give me a little information on how to put up a short-distance telephone about 1,000 feet. I have No. 18 gauge copper wire.

J. L. T., Mayton, W. Va.

ANS.—Use a regular telephone outfit. Line to be mounted on suitable insulators and not close to lighting mains or railway circuits. A ground return may be used if the line is sufficiently removed from foreign circuits containing heavy, or alternating currents.

* * *

(181) (*a*) In the enclosed sketch, *A B* is a straight line passed through the axis of a modern gun. If the gun is fired when its axis is horizontal, will the projectile rise above the horizontal line *A B*, in any part of its flight? (*b*) Show by diagram the path of the projectile from one of the most powerful modern guns. (*c*) How deep will a lead sphere sink in the ocean?

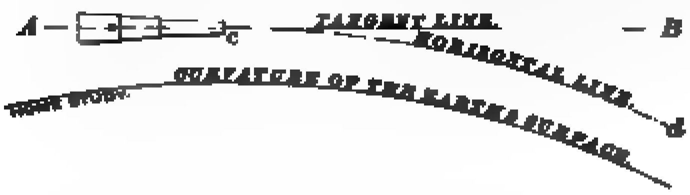


FIG. 1.

(*d*) Will it find the bottom in any and every depth of water? (*e*) Can a glass sphere, the wall of which is 1 inch thick, be forced to a depth at which the pressure of water will be so great as to force the water through the glass into the hollow space in the sphere? M. C. L., Yokohama, Japan, Asia.

ANS.—(*a*) In Fig. 1, *A B* is the tangent to the horizontal line. The horizontal line is not straight, but curved and parallel to the curvature of the earth's surface. When fired from a gun in position shown, the projectile will, at no moment during its flight, rise above the horizontal line *C D*. (*b*) The path of a

FIG. 2.

projectile is shown in Fig. 2 by the full line. The dotted curve represents the theoretical path in vacuum; this curve is a parabola. (*c*) To the bottom. (*d*) Yes. If a body is of such a density that it sinks below the surface of water it will sink to the bottom, no matter what the depth may be. (*e*) We do not attempt to answer questions of so speculative a nature.

* * *

(182) If a railroad train is drawn by two engines of different strokes or different heights of driving wheels, does it make any difference which engine leads? If so, which should be in the lead to obtain greatest economy of fuel and greatest ease in starting or stopping the train? C. P. M., Tyrone, Pa.

ANS.—Considerations other than that of the class of engines employed, generally decide the above point. If a pilot is picked up in the middle of a journey of course it goes on in front. Occasion often arises, too, where an engine has to be returned to another station, "light." To avoid this, it is worked back in front of a regular train. It would be put in front for two reasons: (1) So as to be able to leave the train without delay when the station was reached; (2) so that the regular engineer should have command of the train—in the matter of braking, etc. However, other things being equal, there seems to be no valid reason for giving the preference of position to either one or the other.

* * *

(183) In the article "A Chestnut," published in the November number of HOME STUDY, Mr. Barth applies the load at the eye of the bolt instead of to the sleeve, and arrives, therefore, at erroneous conclusions. The tension on the bolts of a cylinder head is not increased when steam is admitted to the cylinder, provided the initial tension on the bolts is made sufficient to balance the steam pressure.

M. A. T., Milwaukee, Wis.

ANS.—The writer of the article in question fully realized that the conditions of the eye-bolt treated were not in every way *identical* with the conditions of the studs in a cylinder, for the very reason that the

FIG. 1.

depth of a beam is necessarily reduced by the compressing stress due to a load, but as this reduction does not vitiate the general conclusion, but merely has an influence on the magnitude of the additional tension produced, it was thought best not to complicate matters by introducing this phase of the question. This, Mr. Barth considered himself all the more warranted in doing, as it appeared to him that the thoughtful reader would be more likely to

FIG. 2.

entirely overlook the reduction of the depth of a beam due to a load applied, as in Fig. 1, than to get the notion that it would be as great as the reduction produced by two equal and opposite pressures, applied as in Fig. 2, which is apparently the erroneous idea that has led you to condemn the article. In the former case, the compressive stress varies from the full direct amount on top of the beam to zero on its bottom, while in the latter case it is uniform throughout the whole depth. Besides, the idea was more to direct the reader's attention to the general principle, as illustrated without any complications by the eye-bolt treated, than towards its particular application to the cylinder studs.

(184) (*a*) Will you give me some idea regarding the cost of an electric-light station that would be capable of furnishing street lights and lights for private houses in a town having a population of 7,000. In the town there are 3 small foundries, 3 small printing establishments, 7 churches, 3 small hotels, 1 silk mill, 1 woolen mill, 1 opera house, and quite a number of stores and private houses that would make use of the electric light. The town covers an area about 2 miles long by 1½ miles wide. Make allowance for prospects of furnishing power to the 3 printing offices and also power enough to run electric fans in a fair proportion of the stores. (*b*) Are two kinds of motors necessary? What kinds would suit the requirements best?

J. R. B., Fredericksburg, Va.

ANS.—(*a*) About $500 per horsepower, including station equipment, lines, and lamps, excluding motors. Use series arc machines for town lighting. Use the three-wire 110-volt system for house and store lighting. This system will admit of the use of incandescent lamps and enclosed arc-lamps, while 220-volt motors may be placed across the outer mains. (*b*) The motors mentioned will probably be suitable for all your requirements.

* * *

(185) (*a*) What is the "zeretine siccative" referred to in the daily papers in connection with the explosion on the battleship Maine? (*b*) "How would you set the valves of a Corliss engine?" If asked this question *off-hand*, how would you answer it?

S. S., Hudson, Mass.

ANS.—(*a*) At this writing we are unable to give you any information on this subject. (*b*) Adjust the eccentric rod so that the wrist-plate pin will travel an equal distance each side of a position vertically over the wrist-plate center; next, put the engine on its forward center and adjust the crank-end steam-valve rod to give the valve the proper lead, also adjust the crank-end exhaust-valve rod so as to give the exhaust-valve the lead required for a prompt release; finally, place the engine on its back center and adjust the head-end steam-valve rod and the crank-end exhaust-valve rod so as to give the valves the same lead, respectively, as was given for the opposite end. To adjust the cut-off, block the governor up to its usual running position and adjust the rods that operate the trip cams so that each cam will trip its latch at the same relative point in the stroke; if, now, the engine runs too fast, adjust the governor rod so as to make the cams trip their latches earlier in the stroke for a given governor position; if it runs too slow, adjust so as to make the cut-off later.

* * *

(186) We have a compound condensing air-compressor, the high-pressure cylinder is 12″ x 18″ and cuts off at ⅝ stroke; the low-pressure cylinder is 20″ x 18″ and cuts off at ¼ stroke. Will anything be gained by cutting off at ½ stroke in the high-pressure cylinder, or by cutting off at ⅜ stroke in the low-pressure cylinder? The crank on the high-pressure side is 45° ahead of the one on the low-pressure side. The boiler steam pressure is 85 pounds, gauge, and we carry 25 inches of vacuum.

A. H., Rat Portage, Ontario, Canada.

ANS. Owing to the small cylinder ratio, 1 to 2¾, the amount of expansion is comparatively small with the cut-off as late as ⅝ in the high-pressure cylinder, and the proportion of the work done in the low-pressure cylinder is also much greater than that done in the high-pressure. It would be better to cut off at ½, or even ¼, in the high-pressure cylinder as far as economy in the use of steam and equality in the work done by the two cylinders are concerned. This, however, might reduce the power of the engine so much that it would not work the pumps. If you wish to increase the economy without reducing the available power, it can best be done by the use of a larger low-pressure cylinder, say 24 inches in diameter, and cutting off as early in the high-pressure cylinder as will enable the engine to do its work. We cannot say just what the best point of cut-off for the low-pressure cylinder would be without knowing more of the details of the engine; it is probable, however, that ⅜ or ⅝ would give better results than ¼.

* * *

(187) If, as in the figure, I have a square box *a* connected with a steam pipe *b*, and a flat piece of iron *c* so connected that it can be moved about from the outside of the box, will it require more force to move the disk *c* about, if the pressure of steam in the box is increased?

G. W. R., New York City.

ANS.—Yes, because the total pressures on the two sides of *c* are unequal, the difference being due to the fact that the rod *d* is on one side only of the disk *c*. If *d* is 1⅛ inches in diameter, there is 1 square inch less surface for the steam to act upon on the right than on the left side of *c*—a 1⅛-inch circle having about 1 square inch of area. If the steam pressure were 50 pounds per square inch, we should have a net pressure of 50 pounds forcing the disk *c* to the right. The greater the steam pressure, the greater will be the effort of the hand required to move *c* in the direction of the arrow *t*. If the rod *d* were extended on the left side of *c* also, so as to work through the side of box where *b* is, the pressures would be exactly balanced, and the hand could be worked back and forth independent of any alteration of the steam pressure.

* * *

(188) Mr Carl G. Barth makes a mistake in your November HOME STUDY MAGAZINE in his solution of the question, "Is there any tension added to tightly drawn-up cylinder studs, when steam is admitted in the cylinder, or not?" If he would apply his pull to the block on one end and to the eye on the other, his conditions would be like those existing in the question, and he would then find that the way he solves the puzzle is not so correct as it might be.

M. P., Milwaukee, Wis.

ANS.—See answer to question 183 in this number.

* * *

(189) I have read that Prof. Langley's aeroplane engine was of the simplest slide-valve type, single cylinder, 3.3 cm. diameter by 5 cm. stroke; steam furnished from a boiler consisting of helical coil of light, copper tubing about ⅜″ diameter, the water heated by an aeolopile blast of self-distilled gasoline gas. Through this boiler, water was pumped in proper quantity, passing into a separator and thence to the cylinder at pressures varying from 80 to 130 pounds per square inch. At the latter pressure, with a speed of about 800 revolutions per minute, the engine, which, with fire-grate, burners, boilers, pumps, and every moving part weighed less than 7 pounds, developed something over 1 brake-horsepower. (*a*) What is an aeolopile blast of distilled gasoline gas, and how constructed for an engine of this size? (*b*) What would be the plan and dimensions of a boiler and separator, helical coil and pump, grate, burners, etc.?

F. O. F., Presidio, Cal.

ANS.—(*a*) An aeolopile is a form of boiler without tubes. The gasoline in the aeolopile is first heated by some external source and as soon as gas is gener-

ated it passes to a jet beneath the aeolopile which supplies the heat required. The pressure in the aeolopile is sufficient to produce a blast in the fire-box of the steam boiler. (*b*) This question requires too extensive an answer for these columns. Prof. Langley has an account of his work in preparation. It can be obtained when completed by applying to the Secretary of the Smithsonian Institution, Washington, D. C.

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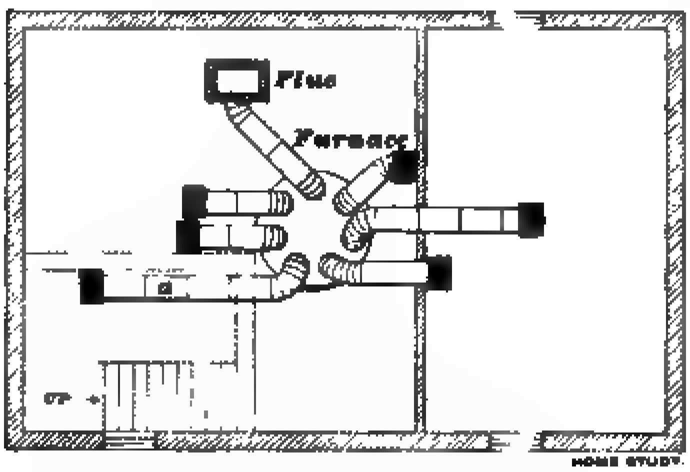
(190) The enclosed sketch represents the basement plan of a building. Can you tell me why every room in the building can be heated satisfactorily with the exception of the hall on the first floor, shown by dotted lines? I cannot get any air through flue *a*. Even if I close the dampers of all the other flues, I get a very slight draft through the hall register.

J. W. F., Chicago, Ill

ANS.—The hot-air furnace that you heat this building with is well designed, compared with many furnaces on the market. Judging by the catalogue cut of the furnace you sent us, and by your description of the work, we believe the trouble does not lie in the furnace. It is evident that there is an obstruction of some description between the furnace dome and the hall register. Just what the obstruction is,



however, is rather a difficult matter to decide without a personal inspection of the work. We advise you to make a close examination of the pipe *a*, and see if it is free and clear from the furnace to the register. Perhaps you will find an old cement bag or a pair of old overalls, or something else of a solid nature, which would choke down the hot-air current to the hall. If it is all clear, you should see that the pipe has a good pitch up from the furnace bonnet to the register box. If the pipe dips down anywhere between these points, the dip should be removed. If there is still no apparent obstruction, then you should lift out the register and see if the register box is deep enough to prevent the mouth of the pipe from being choked by the register frame. If this is the trouble, the hot air should come freely into the hall when the register is out. The pipe *a* is too long to be left bare; it should be covered with a good thickness of asbestos to keep in the heat.

***

(191) Will you please tell me how to make an electric bell, coils, hammer, etc., ready for attaching to the wires from the battery?

G. K., Milwaukee, Wis.

ANS. The illustration shows a construction for a 2½-inch bell to be operated by two or three primary-cells, the number of cells depending on the length of the signal circuit The first construction is that of the cores F and F', which are made of ⅜ inch soft iron to a length of 1¼ inches. By means of machine-screws, each is fastened to the soft-iron bar, or yoke, shown at the left. Over these cores are slipped the coils D, D'. These are made by winding about 60 feet of No. 25 cotton-covered wire on wooden spools. The coils are then so connected together that F and F' are of opposite polarity when the coils are energized. The completed electromagnet is then fastened to the back-board. A flat piece of soft iron G, is next prepared for the armature. A hole is drilled in one end of the armature for the attachment of the hammer, or striker. This striker is made of quite heavy steel wire bent to proper shape, with a piece of brass or iron at one end. The rod may be fastened to the armature and head by soldering, or sweating in: but a screw connection is better. At the other end of the armature G is riveted a steel or brass spring X. This spring is in turn riveted to the post, or block P. The other end of the spring is furnished with a platinum surface, and the adjustment and contact screw M, which is supported by the post N, is also tipped with platinum. T and T' are binding posts, T being connected to the bobbin D, and T' to the post P. A full explanation of the operation of this bell can be found on page 25, in Vol. I of HOME STUDY FOR ELECTRICAL WORKERS.

***

(192) What is a horsepower? How is it figured out? Suppose I want to raise a weight of 1000 pounds 10 feet in one minute, how do I go about figuring the horsepower required to do it?

J. McL., Bloomfield, N. J

ANS.—You will find an article entitled horsepower in this number, wherein you will find information that will enable you to solve any problem of this kind. A horsepower is the capacity for doing 33,000 foot pounds of work in one minute. In this case the horsepower is $\frac{1000 \times 10}{33,000} = \frac{10,000}{33,000} = \frac{10}{33}$ horsepower.

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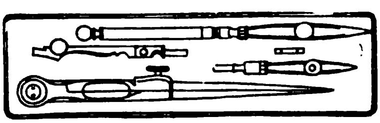

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Vol. III. JUNE, 1898. No. 5.

GAS-ENGINE TESTING.

E. W. Roberts.

THE APPARATUS EMPLOYED—CONSTRUCTION OF A BRAKE—HOW TO TAKE INDICATOR CARDS. MEASURING HEAT WASTES—VALUE OF TEMPERATURE READING—COMPUTATION OF RESULTS.

THERE are occasions when it is advisable or necessary to make a careful study of the performance of a gas engine under various conditions of working. A manufacturer may be seeking defects in order to overcome them, for the defect must be found before the remedy is attempted. Again, the manufacturer may wish a record, to offset any subsequent complaints of the purchaser as to non-fulfilment of guarantees; or, a prospective buyer may wish a test made for the purpose of comparison with other engines on the market, in order to choose the one best suited to his purpose; or, a gas-engine user may have trouble with his engine, and make a test to enable him to locate the trouble, and perhaps test the engine again after repairs are made, to see if the engine is in order.

Nothing will bring out the good and the bad points of an engine like a thorough and accurate test. It enables the engineer to determine if the engine is wasting power, and to discover the cause of the waste. It shows him whether the engine is properly designed as to sizes and proportion of valves and passages, and whether the valves are properly set. It enables him to locate many discrepancies which would otherwise be overlooked, and which long usage would, perhaps, *never* bring to the user's notice.

Although a complete test is often desirable, it is not necessary in every case. For instance, but one thing may be desired, such as the power the engine can deliver to the machinery it is intended to drive. All that is necessary, in such a case, is to make a brake test. In order, however, that the reader may understand the complete test, it will be given in detail, and he may, at any time, select such portions of it as he requires for his purpose.

In a gas-engine test, the following data are those usually taken in order that the performance of the engine may be thoroughly understood.

1. The available power of the engine, known as the delivered horsepower, or the D. H. P.

2. The power given to the piston, by the explosion and expansion of the charge, known as the indicated horsepower, or the I. H. P.

3. The quantity of gas consumed per hour.

4. Power lost, by heat carried away—through the exhaust—by the jacket water—by radiation from various parts of the engine.

From the above data and the measurements that must be made to obtain them, the performance of the engine can be very thoroughly analyzed. To make such a test as just outlined, the apparatus shown in Fig. 1, or its equivalent, is required. A form of absorption dynamometer, known as the *prony brake*, is employed to obtain the D. H. P. The brake shown in the figure consists of the iron strap *a*, to which a number of wooden friction blocks *b* are attached by screws. To each end of the strap is bolted a cast-iron block *c*, so that the brake may be tightened by means of the bolt *d* and the threaded crank *e*. Bolted to *a* are two boards *f*, forming the lever arm, or brake arm, and ending in the steel knife edge *g*. This knife edge rests upon a flat piece of iron *h*, through which the pressure is

transmitted to the platform scale k by means of the stand j.

A simpler form of brake, and one suitable for light powers, is shown in Fig. 2. The brake proper consists of four or five ropes, as shown in the cut, or a piece of leather or canvas belting. The weight w is fastened to one end of the belt and a spring balance b to the other. The lower end of the balance is attached to a hook h, screwed fast to the floor. If the pulley were perfectly free to turn, the reading on the balance would be equal to the weight of w, i. e., if w weighs 50 pounds the pointer on the balance would be at 50.

As the pulley is turned by the engine, the weight w is dragged upwards by the friction of the strap until the strap slips on the pulley. The total amount of pull will then be indicated by the decrease in the reading of the balance, or the difference between the weight of w and the balance reading. Thus, if the balance reads 20 pounds, the pull on the belt would be $w - 20$, or $50 - 20 = 30$ pounds.

The power exerted by the explosion and expansion of the charge is measured by means of the steam-engine indicator i. General instructions for its use always accompany the instrument, and only its application to the gas engine will be treated in this article.

An indicator specially adapted to the gas engine is shown in Fig. 3. The cylinder has two bores a and b. The larger bore a is ½ square inch in area, (the size usually employed when testing a steam engine), the area of the smaller b being ¼ square inch. The piston c is fitted to the smaller bore and is that used when indicating a gas engine. It gives but half the movement of the pencil given by the larger piston used in a, so, if the spring used is stamped 40, the calculations, when using the small piston, must be made as if an 80-pound spring had been used. The pencil movement is also of special design, the moving parts being stronger and more rigid than those used on the regular steam-engine patterns. By the use of the regulation ½-inch piston in a, the indicator may be used for steam-engine purposes.

Fig. 1.

Manufacturers of indicators can usually supply a special paper for use on the indicator. It is known as "metallic paper," and is made by coating ordinary paper with a special preparation which will turn black when rubbed with a brass wire. The indicator pencil may then be replaced by a piece of ordinary brass spring wire and the trouble of keeping a pencil sharp is overcome.

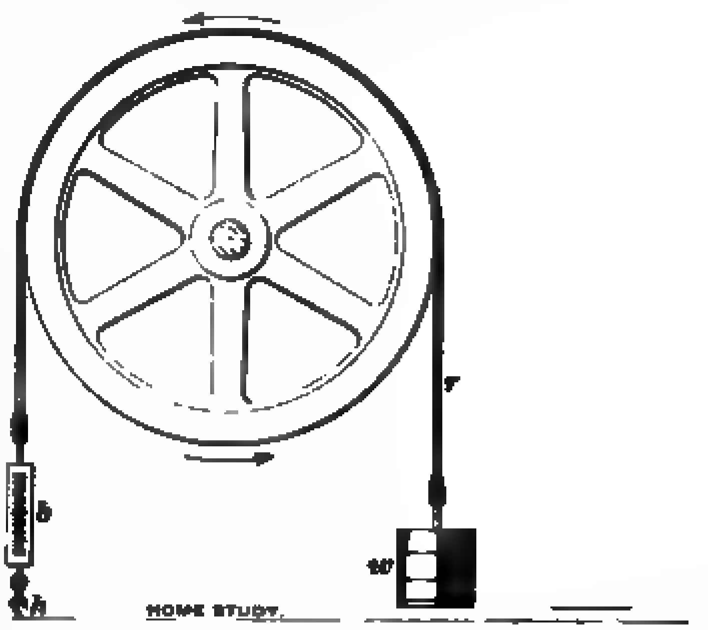

Fig. 2.

Although the preparation of this paper is usually considered a secret, a coating of zinc oxide (zinc white—Chinese white) will answer the same purpose. The zinc oxide should be mixed with some gum solution or

FIG. 3.

glue and spread evenly over the surface of the paper. The paper should be allowed to dry and then subjected to pressure for a day or two to remove the tendency to curl. The surface should be smooth and free from lumps or ridges, as these will cause unnecessary friction. Diagrams made on metallic paper are much more distinct than those made in the old way with a hard pencil.

The small sketch at the right of Fig. 1 illustrates the method of connecting the reducing wheel to the piston. A ¼-inch iron rod *l* is bent at right angles, as shown, and attached to the inside of the piston by two or three small machine screws. The end attached to the piston should, of course, be drawn out flat before the holes for the screws are drilled. A hook is made at *m*, to which to attach the cord from the reductor. The reducing wheel, or speed reductor, can be placed at any convenient point between *m* and the indicator. The cylinder of the indicator *i* is connected to the compression space by ½-inch gas pipe, as shown, a plug-cock *n* being inserted between the engine and the indicator. A bunch of waste saturated with water should be tied around the indicator at *o* and kept wet constantly, in order to prevent damage to the indicator from overheating.

The indicator spring to be chosen depends entirely upon the initial pressure of the exploded charge. The scale of the spring should be such as to give not over 1¾ inches movement to the pencil for the highest pressure to be obtained on the cylinder. For instance, if the initial pressure is 175 pounds, a 100-pound or 120-pound spring should be chosen. The scale of the spring (100 pounds) indicates that the pencil will move 1 inch for each 100 pounds pressure on the piston. In general, it is advisable to select such a spring as will give a diagram between 1¼ and 1¾ inches high.

There are many devices—known as *drum motions*—for reducing the motion of the piston to one suitable for the indicator drum. The reducing wheel *r*, Fig. 1, is perhaps the most convenient for general use. It is shown on a larger scale in Fig. 4, *a* being the cord attached to the rod on the piston, and *b*, that attached to the indicator drum. The smaller pulley can be removed and replaced by one of several others of different sizes. The proportions of the two pulleys should be such that the length of the diagram will be between 2½ and 3½ inches. Thus, if the stroke of the engine is 12 inches, and the desired length of the diagram is 3 inches, the diameter of the

FIG. 4.

larger pulley should be four times that of the smaller.

There should be some means arranged to stop the motion of the drum when not in use. This is easily done by dividing the

cord from the indicator drum to the reducing wheel, and connecting the two portions by means of the loop *l*, and hook *a*, Fig. 5. The knots should be so tied that they will not slip. The small piece of wood *b* makes a very neat arrangement about which to make the loop, as it will not slip and is easily united.

The gas that is supplied to the engine should be measured by an accurate meter, *M*, Fig. 1, reading in cubic feet. A meter having a pointer reading to 10 cubic feet, in single feet, will answer, if readings are taken often enough to note the revolutions of the pointer. The gas from the meter should pass to the engine through an india-rubber gas bag *G*.

When it is necessary to measure the heat wastes and calculate the ratio each bears to the heat supplied, the heating value of the gas should be obtained. Quite frequently, the gas company has a record of the average heating value of the gas they are manufacturing. If they have no such record, a sample of the gas should be sent to the laboratory to be properly tested for this value. This determination is absolutely essential to a complete test, or for a comparison of engines tested with different grades of gas.

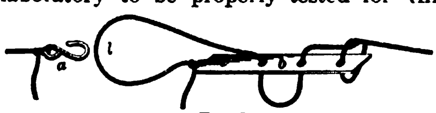

FIG. 5.

In order to ascertain the amount of heat carried off by the jacket water, it is necessary to know the weight of the water which passes through the jacket and the rise of temperature caused by the heat of the engine. The weight of water may be measured in one of two ways. The water may be weighed directly, by means of a platform scale, using a tank or barrel set on the scale platform; or, if the scale is not convenient, the volume may be measured and the weight calculated. Since a certain volume of pure water at the same temperature always has the same weight, it is a simple matter to measure the water directly in pounds. For this purpose the measuring tank *B*, Fig. 1, is so constructed that the depth of the water in inches gives its weight in hundreds of pounds, when multiplied by 2. The tank is made of plank, and is 37½ inches by 37½ inches on the inside. The height may be from 2 to 3 feet, as found most convenient. The stick *s* is marked off in inches or half inches as desired. This is used for measuring the depth of water in the tank. When the bottom of the tank is level, each 2 inches in depth indicates 100 pounds of water and each half-inch shows 25 pounds of water. If the stick is marked off in tenths of an inch, each tenth will indicate 5 pounds of water. The above dimensions are computed for water at a temperature of 110° F. If a smaller tank or more accurate measurement is required, one 26½ inches by 26½ inches would give 25 pounds for each inch on the stick, or 100 pounds for each 4 inches and 5 pounds to each ¼ inch.

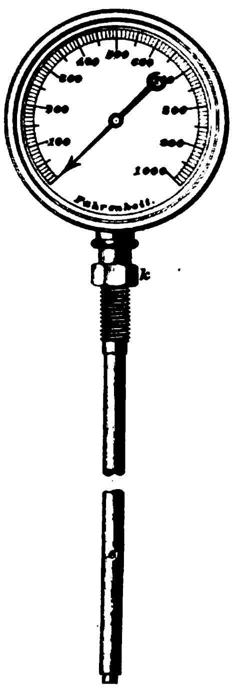

FIG. 6.

Where the quantity of water used is small, or when very accurate determinations are to be made, the water should be weighed. This can be done quite readily by using two receptacles and changing them at the moment of taking the reading. For instance, if the reading is taken every 5 minutes, the stream should be changed from one to the other, just as the signal is given.

The temperature of the entering water is taken by a thermometer at *t*, and that of the discharge at *t′*. The thermometers are not directly in the water, but are surrounded by a small cup containing oil. The

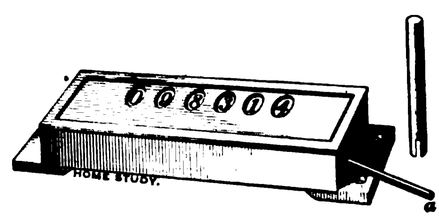

FIG. 7.

temperature of the room is taken by thermometer *T*.

The temperature of the exhaust gases must be taken in order to determine the loss of heat by way of the exhaust pipe.

As these temperatures are too high for the mercury thermometer, a form of temperature indicator known as a *pyrometer* is generally used instead.

A pyrometer is shown in Fig. 6. The

LOG OF TEST.

Gas Engine. Made by

At. *189*

				Temperature, degrees Fah.		Jacket Water.		Wt.	Dynamometer.			Gas.				
Number.	Time.	Rev. per minute.	Explosions per minute.	Room.	Exhaust.	Injection.	Discharge.	Pounds.	Scale reading, pounds.	Net pressure, pounds.	Foot-pounds per revol'n.	Cubic feet.	Pressure inches—water.	M. E. P.	I. H. P.	D. H. P.
1																
2																
3																

stem *s* is composed of two tubes made from metals having different rates of expansion. The metals generally used are copper and iron, the copper tube being placed inside the iron tube, or vice versa. The entire stem from the nut *k* should be subject to the temperature which it is desired to measure. Since the outside tube is heated first, the pointer frequently moves rapidly forward or backward around the dial. As soon as the stem is thoroughly heated, the pointer will indicate the temperature of the stem. A pyrometer is shown at *p*, Fig. 1.

The engineer should be provided with one of the two forms of revolution counter, shown in Figs. 7 and 8. The first is what is known as a *continuous counter*, and the second as a *speed indicator*.

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and the total number
of revolutions registered during that time divided by the number of minutes will give the revolutions per minute.

Fig. 8.

The speed indicator is used as follows: The handle *h* is grasped in the hand and the soft rubber point *p* is thrust into the center countersink on the end of the crank shaft. The dial *d* will then register the number of revolutions. The best way to use this instrument is to have an assistant observe the time. He should give the signal "go" at the beginning of the minute, and say

"stop" just as the minute is up. First set the instrument at zero, or carefully note the reading of the dial. Then hold the point *p* opposite the center, and at the signal "go" thrust *p* into the center, holding it tight enough to prevent it from slipping. Note the number of revolutions of the dial, and at the signal "stop" immediately draw the indicator away from the shaft. As the dial reads to 100, each revolution of the dial will mean 100 revolutions of the crank shaft. Thus, if the dial has made two turns and the pointer is at 50, the number of revolutions is 250.

The number of assistants required when making a gas-engine test depends entirely upon the number and frequency of the readings to be taken. One man should watch the brake, keeping the load constant by means of the crank *e*, Fig. 1. Another should take indicator cards and the speed, and a third should weigh or measure the water, note the temperatures, and read the meter. The latter may sometimes be divided between two observers, making four in all. In special cases one man could take indicator cards and all readings, but such an arrangement is not a good one, because the readings should, if possible, be taken at the same moment. With two observers, readings should be taken every 10 minutes. With three or four observers, readings may be taken every 5 minutes.

It is best to make several separate runs, each with a different load on the brake. Twelve or more readings should be taken with each load, so that, if readings are taken every 5 minutes, the run will last an hour, while, with a 10-minute interval, it will last two hours. At least three runs should be made, one at full load, one at half load, and another with no load. If the engine is a large one, several runs should be made at other loads, in order to obtain the economy of the engine under these various conditions. It is also advisable to know the maximum load the engine is capable of carrying. The sensitiveness of the governor should be determined, where possible, by noting any change of speed when passing suddenly from full load to no load. The person in charge should be provided with a whistle. Thirty seconds before the time for taking the readings, he should blow two blasts on the whistle. Every observer should immediately go to his post. At the moment for taking the readings one blast should be blown, and all readings must, as far as possible, commence at the signal. No looker-on should be allowed to interfere with the observers, and no observer should rely on any one else, particularly an outsider, to take or record the observations allotted to him. Before beginning a trial of any kind, the one in charge should see that a sheet is already prepared for recording the data observed while the trial is in progress. This sheet—called the log—should be ruled in horizontal lines and vertical columns, and each column should be headed with an explanatory phrase or note, showing what particular record is to be recorded in that column. Keeping notes on loose sheets of paper is bad practice. A convenient form of log is shown on the preceding page. There should be lines enough for recording at least 15 sets of observations. Only such observations as are taken during the test, together with the individual results from each reading, should be entered on the log.

(*To be Continued.*)

THE CONDENSER AND ITS USES.

James E. Boyd.

ACTION OF AND HOW TO CHARGE AN ELECTRICAL CONDENSER—ITS APPLICATION TO INDUCTION COILS—CURIOUS RESULT OF ITS SUDDEN DISCHARGE.

AN ELECTRICAL condenser is a contrivance for storing electrical energy in the form of a static charge. Electrical energy may also be stored up by means of a storage battery, but then it is transformed to the energy of chemical combination, while in the condenser the energy remains electrical.

The simplest type of a condenser is shown in Fig. 1. *a* and *b* are two conducting plates of metal, usually tin-foil, and *c* is a sheet of insulating material. The insulating material

is called the *dielectric;* it is generally of glass, mica, paraffined paper, or air.

To charge the condenser, connect one conducting plate to the positive pole, and the other to the negative pole, of the source of electricity, whatever this may be. This is shown in the diagram, Fig. 1. When the key k is closed, current flows from the battery, charging a positively and b negatively. When the key is opened, the condenser retains its charge, provided the insulation is perfect. To discharge it, connect a and b by means of a wire or suitable conductor.

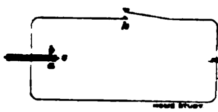

FIG. 1.

Now, it may be asked, why does not the condenser receive a charge with the key k open, since the plate a is connected to the positive pole of the battery? Beginners often make the mistake of attempting to charge a condenser in this way. For instance, a person standing on a dry floor holds the outside coating of a Leyden jar and touches the knob of the jar to one terminal of the electric machine, while the other terminal is insulated. It is found that only a very small spark can be obtained from a jar so charged, which shows that the amount of charge is small. If the floor be damp and the terminal of the machine be connected with it or with the ground, the jar is charged, the circuit represented by k b being that through the floor and operator.

With the key open and a connected with the battery, there is a small amount of electricity which flows to a, about as much as would flow if b were taken away entirely. If, now, the plate b is connected to the negative pole of the battery, negative electricity will flow to it, and this in turn attracts more positive to a, which again attracts more to b, and so on, until the total charge is comparatively large.

Another way of looking at the matter is that shown in Fig. 2. The battery is represented as a pump p, the connecting wires as pipes e and f, and the plates of the condenser as two parts of a hollow cylinder a b. The dielectric c is represented by an elastic membrane, or partition, separating the parts a and b of the cylinder.

Now, in many ways, electricity behaves like an incompressible fluid. (We do not say that it *is* a fluid, but that it behaves as one.) If a battery is forcing current out at one pole, an equal amount must come in at the other. If the circuit is opened so that the current cannot flow in, it ceases to flow out.

Now, suppose that the pump, pipes, and cylinder of Fig. 2 are filled with such an incompressible fluid. Suppose we remove the diaphragm c from the cylinder. This is equivalent to connecting the plates a and b of Fig. 1. We now have little resistance, and a large current will flow.

Now put the diaphragm c in place and again start the pump. Since the diaphragm is elastic, it will be forced upwards, allowing some current to flow into a, and forcing an equal amount out of b. When the diaphragm reaches the point where its elastic force exerts a back pressure equal to the pressure of the pump, motion will cease. In the same way an electric current will flow into a condenser until the potential difference of the plates of the condenser becomes equal to the electromotive force of the battery producing the current.

In Fig. 1, we have a key at the point k; let us see what takes its place in the liquid circuit, Fig. 2. It is evident that the valve v fulfils the same purpose. With this valve *closed,* no liquid can flow from b, and no

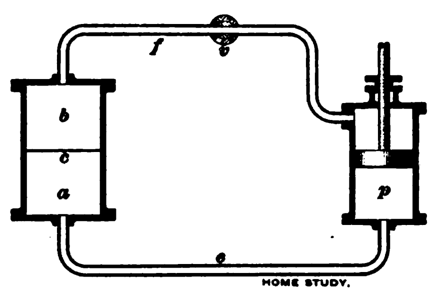

FIG. 2.

matter how much pressure may be put on a, the membrane c cannot move. This is the same as Fig. 1, with the key *open.* In practice we may find that a small quantity of electricity will flow into a when the key is open. This is easily explained. At the key we have what is practically a small condenser in series with the larger one a c b. The insulating material here is the air between the contact points of the key, which themselves represent the plates. If we imagine that the valve v, of Fig. 2, is slightly elastic, so that it will yield somewhat when the pressure is put on by the pump, we have the similar case.

If, with the valve closed, we make connection between a and b, the elasticity of the diaphragm will force liquid through

from a to b. This is equivalent to discharging a condenser by connecting the plates with the battery key open.

The capacity of a condenser is the quantity of electricity, expressed in coulombs, which is necessary to produce a potential difference of one volt between the plates. In a similar way, we might define the capacity of a hollow vessel as the number of pounds of air which it contains when the pressure on the inside is one pound per square inch. If we put in twice as much air, we double the pressure. In the same way, if we double the amount of electricity in the condenser, we double the potential difference of the plates.

FIG. 3.

The practical unit of capacity defined above is called a *farad;* but, since a condenser whose capacity is one farad would be as large as a good-sized house, it is customary to express capacities in microfarads, the microfarad being one-millionth of a farad.

The capacity of a condenser is proportional to the area of the plates. It is evident from Fig. 2 that if the membrane c is pushed forward a certain amount for a given pressure, the quantity of liquid flowing into a and out of b is proportional to the area of cross-section of the cylinder at c.

Also, if the membrane c be thin, it will yield more to the force than if it be thick. It is the same with the dielectric c of Fig. 1. The capacity of the condenser is *inversely* proportional to the thickness of the dielectric. We might imagine the membrane c made of different materials having different elasticities. The greater this elasticity, the greater the amount of liquid which will flow for a given pressure. Now, dielectrics have a property called *specific inductive capacity*, which is similar to this elasticity.

In measuring specific inductive capacity, we take that of air as a standard. Suppose that air is represented in Fig. 2 by a membrane which yields one inch for a pressure of one pound per square inch, and that glass is represented by a membrane which yields three inches for the same pressure; the capacity with the second membrane would be three times what it would be with the first. This number (3) represents the specific inductive capacity of the glass.

The specific inductive capacity of a dielectric is defined, then, as the ratio of the capacity of a condenser with a given dielectric to the capacity of the same condenser with *air* as the dielectric. For example, suppose that two plates of metal are placed close together, as a and b, Fig. 1, and that when the space between them is filled by a sheet of mica, it takes eight times as much electricity to produce a potential difference of one volt as it does when the mica is removed and only air is between them. We would say that the specific inductive capacity of mica is 8.

We know that the potential energy of a vessel filled with a liquid is equal to the product of the mass of the liquid multiplied by the average pressure. If a stand pipe of uniform cross-section is filled with water to the height of 50 feet, the average pressure is equal to 25 feet of water, and the energy in foot-pounds is equal to 25 multiplied by the number of pounds of water in the tank. In a similar way, the energy of the charge of a condenser is equal to the product of the coulombs multiplied by one-half the volts. Algebraically, we say that the energy $= \frac{1}{2} Q V$, where Q is the charge in coulombs and V the potential in volts.

Now, the coulombs are equal to the capacity in farads multiplied by the volts. Expressing capacity by C, this means that $Q = C V$. Then $\frac{1}{2} Q V = \frac{1}{2} C V^2$, or the energy of the charge is equal to one-half the product of the capacity multiplied by the square of the potential.

Suppose we have a condenser of one microfarad capacity charged to 1,000 volts. The energy would be $\frac{1}{2} \times .000001 \times 1,000^2 = \frac{1}{2}$. This means that this charge represents as much energy as a current of one ampere flowing for *one second* in a resistance of one-half ohm. It is evident, then, that the amount of energy represented by a charged condenser is very small.

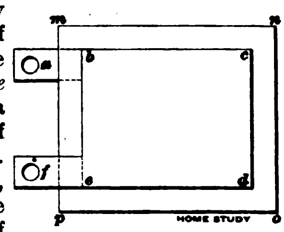

FIG. 4.

It is desirable to have the plates in a condenser of large area and the insulation thin. If the insulation is made too thin, however, it may break down and permit the current to flow through. The condenser then becomes a conductor and is of no further use.

The plates of condensers are generally sheets of tin-foil, and the dielectric is mica or paraffined paper. These are arranged as shown in Fig. 3. Here the lines represent the sheets of tin-foil, and the blank spaces between them the insulation. The even numbered sheets are connected together to one terminal, and the odd numbered ones to the other. When the condenser is charged, each sheet is inserted between two sheets having the opposite charge. In the diagram we have sheet *2* positive between *1* and *3* negative, and *3*, which is negative, between *2* and *4* positive. By this arrangement we get a charge on both sides of each sheet (except the two outer ones).

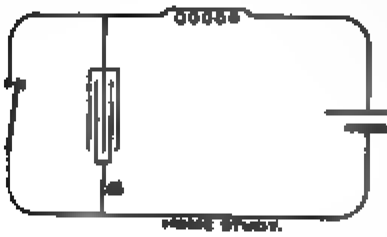

FIG. 5.

The usual method of constructing condensers is shown in Fig. 4. Here *a b c d e* represents a sheet of tin-foil. Upon this is laid a somewhat larger sheet of paraffined paper *m n o p*. Upon the paper comes a second sheet of tin-foil *f e d c b*. The projections *a* and *f* are connected to the terminals of the condenser. In this way the whole condenser is built up of sheets connected alternately to *a* and *f*. The condenser is finally placed in a wooden box for protection against injury.

One important use of a condenser is to take up the current when a circuit is suddenly opened. If a current of water is flowing with a high velocity in a pipe, and the pipe is suddenly closed, the inertia of the mass of moving water may be sufficient to burst the pipe. In the same way an electric current possesses something similar to inertia. The more electromagnets there are in the circuit, the greater the inertia. Whenever the current is changed in any way, this inertia produces an electromotive force, or electrical pressure, called the electromotive force of self-induction. When the current is stopped, it produces a pressure tending to keep the current going in the same direction. The more suddenly the current is stopped, the greater is this pressure, just as it is with a flowing liquid.

When a switch is opened in a circuit having large self-induction, we have a large electrical pressure tending to break down the insulation of the circuit. It usually does break down the air between the contact points of the the switch, giving an arc. This arc, which is intensely hot, rapidly destroys the contacts.

To prevent this trouble we use a condenser, one end of which is connected to one side of the switch and the other to the opposite side, as shown in the diagram, Fig. 5. With this arrangement, when the switch is opened the current rushes into the condenser, instead of jumping across the air gap. The current *gradually* stops as the condenser is charged, and the electromotive force of self-induction does not reach a high value.

Fig. 6 represents a similar case with a flowing liquid. If the opening at *e* be suddenly closed, the inertia will carry the liquid up into the chamber *c*, compressing the air in it. The kinetic energy of the moving liquid is thus changed to potential energy of compressed air, and this is given up again when *e* is reopened.

A condenser is used in this way at the contact points of an induction coil. It is used, too, in signaling devices, in which a telegraph relay is made to break a large current.

An interesting example of this occurred in the writer's experience. An ordinary telegraph relay was arranged to make and break a circuit of large self-induction, in which the current was about $\frac{1}{4}$ ampere and the potential 80 volts. When a condenser was put across the terminals, as in Fig. 5, it was found that the contacts stuck together when the circuit was closed. This was due to a sudden rush of current from the condenser on closing the circuit, which fused the platinum contact points. The condenser being charged to a potential of 80 volts, and the resistance of the circuit from condenser through contacts being very small, it was possible to have a current of several amperes for a short time. A 50-volt lamp was put in series between the contact and the condenser (at the point *a*, Fig. 5), and the relay worked satisfactorily. The resistance of the lamp caused the current to flow more slowly from the condenser, just as a long tube *a*, Fig. 6, would cause the liquid to flow slowly out of *c* when *e* is opened.

FIG. 6.

STADIA SURVEYING.

Antonio Llano.

THE LAW OF REFRACTION AND ITS APPLICATION TO STADIA SURVEYING—SHORT METHODS FOR THE DETERMINATION OF HORIZONTAL AND VERTICAL DISTANCES.

BEFORE *defining* stadia surveying, we will *show* what it is. Two branches of science are applied in this method of surveying; namely, physics and geometry. Physics furnishes the laws of refraction applied in the construction of the instruments used; geometry shows certain relations that follow from those laws, by means of which the instruments may be made to serve special purposes.

If a ray of light R, Fig. 1, passes from a medium M to a medium M', as from air to water, or from vacuum to air, it experiences a deviation from its original direction. This deviation is called *refraction*. In the figure, $P\,Q$ is a normal, or perpendicular, to the surface $S\,T$ common to the two media. The ray R is called the *incident ray;* the deviated ray R' is called the *refracted ray;* and i and r are called the *angle of incidence* and the *angle of refraction*, respectively. The law of refraction is that, so long as the two media remain the same, the ratio of the sine of the angle of incidence to the sine of the angle of refraction remains the same, whatever the direction of the incident ray may be. This ratio is called the *index of refraction* of the two media, and is usually denoted by n. Algebraically, the law is expressed by the equation

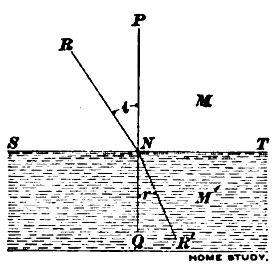

FIG. 1.

$$\frac{\sin i}{\sin r} = n.$$

The value of n is determined experimentally. When it is given for any solid or liquid substance, without reference to any other substance, it is understood that the rays pass from air into the substance in question. Thus, by saying that the index of refraction of flint glass is 1.702, we mean that, when a ray of light passes from air into flint glass, the ratio of sin i to sin r is 1.702.

In Fig. 2, $L\,L$ is a lens, $P\,P'$ its axis, and R, R are parallel rays of light (solar rays, for instance). It is shown in physics that these rays, after being refracted by the lens, converge at a point F on the axis, such that the distance $F\,Q'$ from F to the lens is equal to $\frac{r\,r'}{(n-1)(r+r')}$, in which r and r' are the radii of $L\,Q\,L$ and $L\,Q'\,L$, respectively, and n is the index of refraction of the lens.

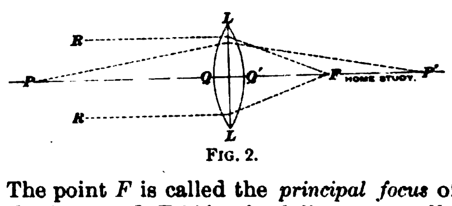

FIG. 2.

The point F is called the *principal focus* of the lens, and $F\,Q'$ its *focal distance*, usually denoted by f.

It is further shown that the rays from any point P on the axis converge, after refraction, at another point P', and that the distances $P\,Q$, $P'\,Q'$, and $F\,Q'$ are related by the formula

$$\frac{1}{P\,Q} + \frac{1}{P'\,Q'} = \frac{1}{F\,Q'},$$

or, putting $\quad P\,Q = p,\ P'\,Q' = p'$,

$$\frac{1}{p} + \frac{1}{p'} = \frac{1}{f}. \qquad (1)$$

The image of a point at P forms at P', and the image of a point at P' forms at P; hence, these two points are called *conjugate foci*. As the lens is always very thin, compared with the distances $Q'F$, $P\,Q$, etc., these distances are taken to either face of the lens, neglecting the thickness of the latter.

The object glass of the telescope of a transit consists of two lenses, as shown in Fig. 3: a double-convex lens L, and a concavo-convex lens L'. As in the case of a single lens, the focal distance for parallel rays is constant, and the relation between the distances of an object and its image from the lens is expressed by an equation of the same form as equation (1). The object of the combination is to avoid the formation of images with colored edges, owing to the fact that light, when passing

through a lens or prism, is decomposed into its elementary colors (the colors of the rainbow); each color, or ray, has a different focus, and the image formed is indistinct. But, by a proper combination of lenses, the rays are again made to converge at a common focus, and give a well defined image. The decomposition of light by a lens or prism is called *chromatic aberration.* A compound lens, such as the object glass of the transit, in which the various rays are recombined, is called an *achromatic* lens.

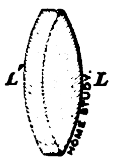

FIG. 3.

As the thickness of the object glass is too small to be considered, we may represent it merely by a line.

In Fig. 4, let L be the object glass, $A\ B$ a portion of a rod, $a\ b$ the inverted image of $A\ B$, and f the focal distance of the lens or lenses L. It will be remembered that the image $b\ a$ is again erected by the eyepiece; but this has no bearing on the present subject. Also, the lines $A\ C$ and $C\ a$ are not really the same straight line, but two parallel lines; however, as the lens is very thin, $A\ C$ and $C a$ are here drawn as one line. The same applies to $b\ C\ B$. From formula (1) we have

$$\frac{1}{C m} + \frac{1}{C\ M} = \frac{1}{f};$$

whence $$\frac{1}{C m} = \frac{1}{f} - \frac{1}{C\ M}.$$

Also, from the similar triangles $a\ C\ b$ and $A\ C\ B$,

$$\frac{a\ b}{C\ m} = \frac{A\ B}{C\ M};$$

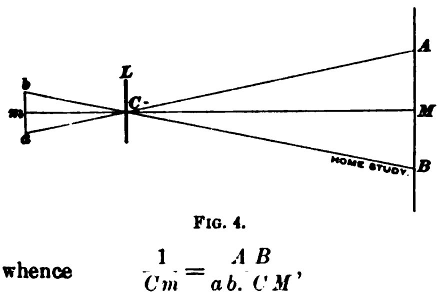

FIG. 4.

whence $$\frac{1}{C m} = \frac{A\ B}{a\,b.\ C\ M},$$

which, combined with the first value of $\frac{1}{C\ m}$, gives

$$\frac{A\ B}{a b.\ C\ M} = \frac{1}{f} - \frac{1}{C\ M}.$$

From this there follows,

$$C\ M = \frac{f}{a\ b} \times A\ B + f. \qquad (2)$$

As f is constant, it is seen that the distance $C\ M$ depends only on two variable quantities, $A\ B$ and $a\ b$; and, if we succeed in making $a\ b$ constant, then we may calculate the distance $C\ M$ without measuring any other distance than the space $A\ B$ on the rod. Such is the object of stadia surveying —that is, to ascertain the distance from the instrument to an object by making the refracted image of a part of the object equal to a fixed length. This is accomplished in a very simple manner. To the ordinary cross-wires $c\ d$ and $h\ k$ (Fig. 5) on the diaphragm, or reticule, of the telescope are added two horizontal wires $p\ q$ and $m\ n$, equally distant from the center wire $h\ k$.. These wires are called *stadia* wires. As the image is always made to fall on the reticule, by sliding the object piece in or out, that part intercepted between $m\ n$ and $p\ q$ is always the same.

In Fig. 4, $a\ b$ corresponds to $a\ b$ of Fig. 5, the points a and b being the intersections of the refracted image of the rod with the two stadia wires $m\ n$ and $p\ q$. As the eye glass has no other object than to erect and magnify the image, it has no influence on the relations of equation (2). If in this equation we write a for the distance $a\ b$ between stadia wires (Fig. 5), r for the reading $A\ B$ of the rod, and d for the required distance $C\ M$, we get the formula

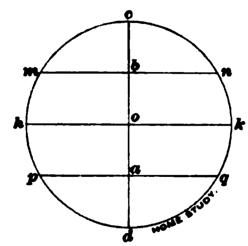

FIG. 5.

$$d = \frac{f}{a} r + f. \qquad (3)$$

The rod $A\ B$, when used for this purpose, is called a *stadia;* so that *stadia surveying* is simply surveying by means of a graduated rod and a transit provided with stadia wires. Both horizontal and vertical distances can be calculated by means of this combination, as we shall presently see.

The distance d of formula (3) is measured *to the object glass.* The distance *to the center of the instrument,* that is, practically, to the point of the plumb-bob, is equal to $d + c$, where c is the distance from center of instrument to object glass. This distance varies slightly, as the object piece is slid in or out for focusing, but the changes are so small that c may be taken as constant, and the true required distance may be written,

$$D = d + c = \frac{f}{a} r + f + c.$$

The constants $\frac{f}{a}$, f, and c are generally

furnished by the instrument maker, $\frac{a}{f}$ being customarily made equal to 100, so that $D - (f + c) = 100\,r$, or, for approximate work, $D = 100\,r$. The value of c is usually equal to $\frac{f}{2}$. It is, however, better to determine these constants directly. A good method of doing this is the following:

Let $\frac{f}{a} = k$, and $f + c = k_1$. Then the value of D is

$$D = kr + k_1. \qquad (4)$$

After setting and leveling the transit, run a line of, say, 1,000 feet, on ground as level as practicable, taking care that the atmospheric conditions are favorable. (Refraction is least between about 8 and 10 A. M., and increases with the temperature). Set the rod at distances of 50′, 100′, 200′, etc., measured along the line from the center of the instrument (point of plumb-bob), and read very carefully the space intercepted by the stadia wires at each setting of the rod. Then, the distances and the corresponding readings may be taken in pairs and substituted in equation (4); from each pair a value is found for k and one for k_1; then the means are taken of all the values of k and of all the values of k_1.

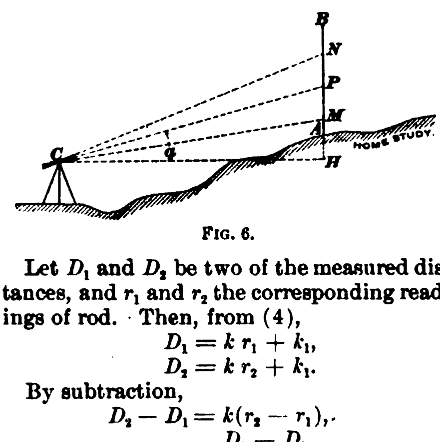

FIG. 6.

Let D_1 and D_2 be two of the measured distances, and r_1 and r_2 the corresponding readings of rod. Then, from (4),

$$D_1 = k\,r_1 + k_1,$$
$$D_2 = k\,r_2 + k_1.$$

By subtraction,

$$D_2 - D_1 = k(r_2 - r_1),$$
$$k = \frac{D_2 - D_1}{r_2 - r_1}. \qquad (5)$$

Also,

$$\therefore k_1 = D_1 - k\,r_1 = D_1 - \frac{(D_2 - D_1)r_1}{r_2 - r_1},$$

or, reducing, $$k_1 = \frac{D_1 r_2 - r_1 D_2}{r_2 - r_1}. \qquad (6)$$

In determinations of this kind, the rod should be read at least to thousandths by means of a vernier. Although it is easier to find k_1 by the formula $k_1 = D_1 - k\,r_1$, it is advisable to find it independently by formula (6).

As an illustration we shall give the following example, in which the data are tabulated:

DISTANCE MEASURED.	READING OF ROD.
50′	.485′
100′	.985′
200′	1.985′
300′	2.988′
400′	3.984′
500′	4.987′

Taking 50′ for the value of D_1, and 100′, 200′, etc. successively for the value of D_2, and applying formulas (5) and (6), we find:

First, for $D_1 = 50$ and $D_2 = 100$,

$$k = \frac{100 - 50}{.985 - .485} = 100.000',$$
$$k_1 = \frac{50 \times .985 - .485 \times 100}{.985 - .485} = 1.500'.$$

Second, for $D_1 = 50$ and $D_2 = 200$,

$$k = \frac{200 - 50}{1.985 - .485} = 100.000',$$
$$k_1 = \frac{50 \times 1.985 - .485 \times 200}{1.985 - .485} = 1.500'.$$

Third, for $D_1 = 50$ and $D_2 = 300$,

$$k = \frac{300 - 50}{2.988 - .485} = 99.880',$$
$$k_1 = \frac{50 \times 2.988 - .485 \times 300}{2.988 - .485} = 1.558'.$$

Fourth, for $D_1 = 50$ and $D_2 = 400$,

$$k = \frac{400 - 50}{3.984 - .485} = 100.028'.$$
$$k_1 = \frac{50 \times 3.984 - .485 \times 400}{3.984 - .485} = 1.402'.$$

Fifth, for $D_1 = 50$ and $D_2 = 500$,

$$k = \frac{500 - 50}{4.987 - .485} = 99.956,$$
$$k_1 = \frac{50 \times 4.987 - .485 \times 500}{4.987 - .485} = 1.521'.$$

Tabulating the results,

	k	k_1
	100.000	1.500
	100.000	1.500
	99.880	1.558
	100.028	1.402
	99.956	1.521
	5) 499.864	5) 7.481
Means	99.975	1.496

The mean values in formula (4) give

$$D = 99.975\,r + 1.496.$$

For ordinary topographical work, however, especially for long distances, it is sufficiently close to take $D = 100\,r$.

The preceding formulas assume that the line of sight is horizontal, or perpendicular to the rod. When the line of sight is not

horizontal, the rod may be held perpendicular to it; but this is inconvenient and inaccurate, and it is better always to hold the rod vertical, and apply a different formula from formula (4) as follows: In Fig. 6, AB is the position of the vertical rod; $MN = r$ is the space covered by the stadia wires of the transit C; and a is the angle of elevation, measured on the vertical circle of the instrument. Then, by a few simple trigonometric transformations, it can be shown that the *horizontal* distance $D = CH$ is, practically,

$$D = kr\cos^2 a + k_1 \cos a. \qquad (7)$$

When the angle of elevation a is small, say less than 5°, no correction need be made, unless great accuracy is desired; that is,

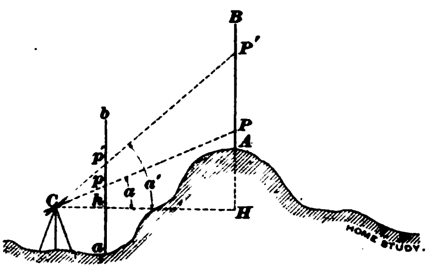

FIG. 7.

formula (4) may be used instead of formula (7). The error arising from this omission is 1% in the case of an angle of 5°, and much less for smaller angles.

The elevation of P above C is

$PH = D\tan a$,

or, substituting the value of D from (7), and remembering that $\tan a = \frac{\sin a}{\cos a}$, and $\sin a \cos a = \frac{1}{2}\sin 2a$,

$$PH = \tfrac{1}{2}kr\sin 2a + k_1 \sin a. \qquad (8)$$

A convenient way of measuring long distances by means of rod readings, but without stadia wires, is illustrated in Fig. 7, where C is the position of instrument, and A is the point whose distance and height are required. Hold the rod vertical at A; sight at two convenient points of rod, setting the middle wire of transit at P and P' respectively, at the same time measuring the angles of elevation a and a'. Let rod reading $PP' = r$. Then,

$$\tan a' = \frac{P'H}{CH},$$

$$\tan a = \frac{PH}{CH};$$

whence, by subtraction,

$$\tan a' - \tan a = \frac{P'H - PH}{CH} = \frac{r}{CH},$$

and

$$CH = \frac{r}{\tan a' - \tan a}. \qquad (9)$$

Also,

$$PH = CH\tan a = \frac{r\tan a}{\tan a' - \tan a}. \qquad (10)$$

If the transit has no vertical circle, measure a convenient distance Ch, say 50 or 100 feet, and hold there a rod or pole (a stick will do); measure distance $pp' = r'$ intercepted by lines CP, CP'.

Then, by similar triangles,

$$PP' : pp' = CH : Ch;$$

whence

$$CH = Ch \times \frac{PP'}{pp'} = Ch \times \frac{r}{r'}. \qquad (11)$$

If there is a level attached to the telescope, the intersection h of a level line with the auxiliary rod ab may be marked, and the distances hp, hp' measured. Then we have, $\frac{hp'}{Ch} = \tan a'$, $\frac{hp}{Ch} = \tan a$, and formulas (9) and (10) may be used.

The stadia method of surveying is of great value in topographical, hydrographical, and other kinds of field work. The accuracy of the results is affected both by the reading of the rod and the conditions of the atmosphere, the latter introducing the variable error of refraction. With a good instrument, and under favorable atmospheric conditions, the total error may be as low as 0.1%, and seldom as high as 1%. It is greater for long lines, especially if the temperature is high and the atmosphere unsteady. For almost all practical purposes, the term k_1 of equation (4) may be neglected, and, as k is usually equal to 100, the distance is easily found by multiplying the rod reading by 100. For a closer approximation, 1 foot may be added to the result thus found, as this is about the value of k_1 in all ordinary instruments.

A LESSON IN DUST.

An Hour with Jacobus Allen, Heating Engineer.

Thomas N Thomson

I AM reclining in my office chair with legs stretched out on the level to ease them a little, and help the blood to circulate freely.

Outwardly, no doubt, it would appear that I am taking things easy, but inwardly I am worrying over the lay-out of a heating and ventilation job, which must be designed, contracted for, erected, and completed within three months from date. The building is about three blocks down the way—built on a busy street where traffic is heavy. The owner seems to think that "anything will do" so long as he can get heat during winter; but I know only too well that this will not fully satisfy him when the tenants are all moved in. Don't I know that there will be thousands of dollars' worth of very delicate machinery in that building some day soon? Don't I know that such machinery must run clear and free from dust? Don't I know that the atmosphere of the street—and all around the building too, for that matter—is highly charged with dust, and that this is so in spite of the fact that the owner says "no, no; there is no dust there, man; the streets are washed every night, and I will have a good janitor in the building"? Such stuff! nonsense! bosh! The whole city is full of dust! Just look at that, now!

Here I am, sitting alone in a private office —dimensions, 20′ x 15′ x 12′—with two windows looking over the back roof, and two doors for admission to or from the corridor in the heart of the building. The windows are closed and the doors are shut. Sunshine streams into my dingy den through that window in front of me and seems to mock us all. See the dust glisten! See the particles dodge between the sunbeams and sparkle like millions of little stars! See how they move in small spasmodic currents, this way, that way, every way! There they go whirling, and twirling, and waltzing around to beat the band! Why don't they settle down anyhow and lie on the floor? I have not moved from this chair now for—let me see—a quarter of an hour at least, and still they dance in the sunlight. I

cannot see a speck of dust anywhere in the room except in the path of the sunlight. Ah, it requires the search light of the Great Architect of the universe to let us see where we stand, and show us that we are not so much after all. There is no dust visible anywhere, except in the rays from this search light. Great Scott! see that long one rising up close by the glass, a regular fiber, shining like a hair from a silver fox.

My office boy now opens the door and ushers in Mr. Grimes, the owner of the building in question, and his architect, Mr. Brush; they have come to consult with me about the proposed heating system; I am glad they have come, because now we can talk ventilation to advantage.

"Good morning, Mr. Allen," says the owner, "Mr. Brush and I have been talking over this ventilation business, and I think we should omit it altogether. We can heat the building with direct steam radiators alone, and in that way avoid all dust and dirt from the street. You see, I would like very much to connect these big air flues, which Mr. Brush has already built, into extensions to the present safe vaults, but Mr. Brush objects to my ideas, so we decided to consult with you."

"Now, Mr. Allen," says the architect, "I will give you the conditions in a nutshell. First, this building although large, has no room to spare for any unnecessary apparatus. Every square foot of the floor surface is valuable. Second, there will be a large number of employees in each room, all engaged in a business which will require incessant care and thought, and they must have fresh air to keep them from falling asleep at their work. Third, the apparatus which they operate must be kept at a nearly uniform temperature and must be kept dry and perfectly clean. It would appear to me that we must ventilate this building thoroughly, as well as heat it, and I am sure that direct steam radiators, if anything, must not be used."

"Now, Mr. Allen," says the owner, "just gather your brains together and let us hear what you have to say on the subject."

By this time the sun's rays are streaming in through the window about at right angles with the face of the wall, and the dust is whirling about more than ever, so, after a moment's thought, I decide to commence by giving these gentlemen a lesson in dust. "Gentlemen, if you will grant me a few minutes of your valuable time I will endeavor to show you the necessity of ventilating your building. Let us watch the dust floating in the air over there where the sun shines into the room—do you notice how thick it is?"

"Yes, but what has that got to do with our case?" asks Mr. Grimes.

"This particular dust," I remark, "has nothing to do with your case, but the dust in your own building will. This dust here will suffice to show us what will happen in your building if you use direct radiation for heating, and if you do not ventilate the rooms properly with clean air forced through clean flues by a special ventilating plant. Now you will surely admit that the air outside of this building is as clear and free from dust as it is around your new building."

"I admit that," says Grimes.

"Well, this is a mild day outside, and on such days the employees of the company who will rent your building will surely open the windows for fresh air, and the street dust will certainly blow in with the fresh air. Now, I will open this window and see if the dust blows in here." So saying I raised the lower sash about 15 inches, and we all sat down to watch the result. The air in the room immediately begins to flow out through the window slowly and steadily and of course an equal volume is coming in from the corridor through the keyholes and the openings around the doors. Suddenly a gentle breeze eddies around the corner of the building and causes air to flow in through the open window. The amount of dust in this fresh air is simply alarming and we can see it well as soon as it enters the room. The duration of the inflow of fresh air, however, is brief, the wind changes again and the current is suddenly reversed.

"Now," says Mr. Grimes, "I see your point and it is well taken, but, my gracious, how plain we can see the dust here. Do you think it will be as bad as that down our way? Look at that, will you! Let us place a sheet of paper on the floor and see if we can catch any of it."

Pushing the button for the office boy, I assured Mr. Grimes that it would probably be *worse* than this down at his building, because his is a corner building and more exposed to wind than we are here.

"Johnny," I say to the office boy, "go over to the toilet room and take down the mirror, take a cloth with a little alcohol and polish up the glass and bring it in here at once."

While Johnny is gone for the mirror, Mr. Brush corroborates my statements about the dust, which is liable to enter the rooms

of Mr. Grimes's new building if the windows are opened; also emphasizing the fact that the machines and instruments that will be used in the new building must be protected from dust while the employees are operating them, otherwise they will soon be ruined. He still further declares that the only way to do this is to prevent the dust from entering the rooms, and also to prevent the generation of dust within the rooms themselves. But here comes Johnny with the mirror at last.

"Now, gentlemen, please cast your eyes obliquely over the surface of this glass and see if it is perfectly free from dust," say I, handing the mirror to Mr. Brush, who in turn passes it to Mr. Grimes, with the remark that it is perfectly clean. Mr. Grimes says that it appears to be perfectly free from dust, and hands it back to me. Now I lay it on the floor just under the open window, and pull down the upper sash about 2 feet, thus making two openings between the room and the outer atmosphere. The air near the ceiling immediately flows out through the top opening, and a corresponding volume of fresh air, heavily charged with dust, flows in through the lower one. An occasional eddy blows in such clouds of dust that Mr. Grimes can hardly believe his eyes. I did not think for a moment that our experiment would be so successful. The flocculent dust remained suspended in the air, while the more solid dust slowly fell to the floor, and we could clearly see it settle. In a few minutes Mr. Grimes becomes impatient, and suggests that we examine the mirror now. Mr. Brush picks it up and lays it on my desk. Mr. Grimes draws his finger over the surface of the glass, and there, sure enough, he can write his name in the dust.

"That settles it, Mr. Allen; just go ahead and install a system of ventilation which will furnish clean air to each and every room of the new building all the year around; and you, Mr. Brush, I think, should make all the windows tight, so that the employees cannot open them at all. It might be well also to fit the doors closely, so that no dust can get into the rooms from the corridors; and, gentlemen, do whatever you think is necessary to make the new building dust-proof. Good bye."

So saying, Mr. Grimes bowed himself out and left us alone to scheme out ways and means of filling his order. We soon decide upon a definite plan for ventilating the building, and I immediately place it on the "trestle board." We allow screens for straining and washing the air before it blows into the rooms, and arrange for all air flues which carry the air from the blower to the several rooms being lined with sheet metal, to prevent any particles of lime or brick inside the flues from being blown into the rooms. Then Mr. Brush takes his departure. We three each had a good lesson, and you see what is the outcome of it.

And now, dear reader, that you and I are alone, let us recapitulate and see what we have learned by watching the dust. First, we learn that under ordinary conditions the air may be impregnated with light dust, even though none is visible. Second, that sunshine streaming into a dimly lighted room, through a window or small opening, will make the dust visible to the naked eye. Third, though the air in a room may be apparently at rest, it is really in motion all the time; this is observed by the constant movement of the dust when everything else in the room is still. Fourth, that dust particles vary in size—some are so small as to be scarcely visible when standing close to them, while others can be seen easily from a distance of 15 feet or more. And, furthermore, that the dust does not settle according to its size. Fifth, that by opening a window to get fresh air into the room, a large quantity of dust is carried in with the air and settles in the room. Sixth, that the air in an ordinary room can be slowly changed by opening a window from the bottom. This is observed by the dust flowing either in or out according to the direction and pressure of the air currents outside the building. Seventh, that the air in a room can be rapidly changed by opening a window both at the top and bottom, and that, under ordinary conditions, the inlet of fresh air is at the bottom, while the outlet is at the top; also, that a room in a city building located on a busy street cannot be kept clean and free from dust when this method of ventilation is employed, because the dust from the streets is churned up with the outer air by the street traffic and by wind. Eighth, that before we can have clean air inside such a city building we must cut off all open communication between the inner and outer air, and supply *clean* air—thoroughly screened and washed—by means of a proper system of ventilation, which will operate positively and successfully every month of the year. This is done in some of the finest city buildings of today; of course, "it comes high," but in some cases we've got to have it.

PLANE MOTION.

George A. Goodenough.

NUMBER OF INSTANTANEOUS CENTERS—HOW CENTERS ARE LOCATED BY DRAWING STRAIGHT LINES—USE OF THE INSTANTANEOUS CENTER.

PART II.

EVERY link of a mechanism has a motion relative to every other link, and, as shown in April number, in Plane Motion, Part I, every one of these motions is a rotation about a center either permanent or instantaneous. In order, therefore, to completely investigate the motions of the various moving parts of a mechanism, to determine the linear velocities of various points or the angular velocities of the links, it is necessary to locate some or all of the instantaneous centers. We shall in this article attempt to develop a general method for finding any desired center or centers.

We first inquire as to the number of centers in a mechanism with a given number of links. First, suppose a mechanism has three links a, b, and c. Each link has a motion relative to each of the other two; thus, a has a motion relative to b which gives rise to the center $(a\,b)$, and a motion relative to c about the center $(a\,c)$.

In this and any future article, the center belonging to two links will always be denoted by enclosing in parenthesis the letters denoting the links, thus: $(a\,b)$, $(c\,d)$, etc.

For this system of three links there are evidently three centers, viz.. $(a\,b)$, $(a\,c)$, and $(b\,c)$. Let us, for convenience, arrange them in the form of a triangle, thus:

$$\begin{array}{cc} (ab) & (ac) \\ & (bc) \end{array}$$

For a mechanism with four links, a, b, c, and d, there are six centers, which may be arranged in the following form:

$$\begin{array}{ccc} (ab) & (ac) & (ad) \\ & (bc) & (bd) \\ & & (cd) \end{array}$$

The formation of the table of centers is obvious: in the first line the letter a is paired with each of the remaining letters b, c, and d; in the second line the letter b is paired with each of the letters c and d which follow it, and so on.

If we add a fifth link e to the mechanism, we must add to the table of centers another vertical row, containing the centers of link e with respect to each of the other links. The table becomes:

$$\begin{array}{cccc} (ab) & (ac) & (ad) & (ae) \\ & (bc) & (bd) & (be) \\ & & (cd) & (ce) \\ & & & (de) \end{array}$$

Thus, for five links there are ten centers. If we must add still another link f, we must add a fifth row containing five new centers, making fifteen in all for the six links. In general, we shall find that if the mechanism contains n links there are $\frac{n(n-1)}{2}$ centers. For example, a mechanism with 12 links has $\frac{12 \times 11}{2} = 66$ centers.

The location of the centers is accomplished by the aid of the principle that the three

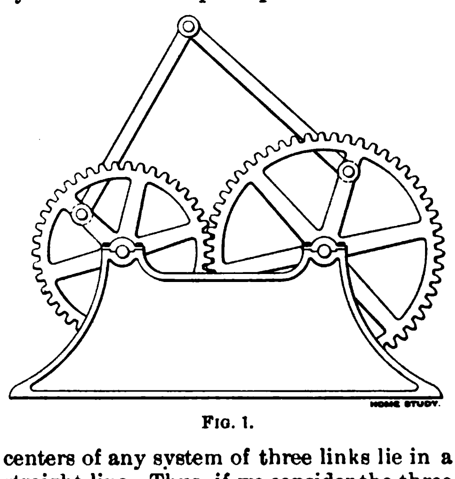

FIG. 1.

centers of any system of three links lie in a straight line. Thus, if we consider the three links a, b, and d, we obtain, by taking them in pairs, the three centers $(a\,b)$, $(a\,d)$, and $(b\,d)$, and according to the law given in the previous article, these centers must lie in a straight line.

The process of finding the unknown centers may be best illustrated by an example. In Fig. 1 is shown a mechanism composed of two spur gears, two straight links, and a frame or bed to which the gears are connected. The mechanism has thus five links and $\frac{5 \times 4}{2} = 10$ centers, which we will now attempt to locate. For the sake of clearness,

the mechanism is shown in a skeleton form in Fig. 2, and the links are lettered as shown. The fixed frame a is represented by the single line connecting the centers of the gears, and the gears are represented simply by the circles b and c. We first form the following table containing all of the centers, and indicate those centers that are at once known by underscoring them with dashes.

$$\begin{array}{cccc} (ab) & \underline{(ac)} & (ad) & (ae) \\ & \underline{(bc)} & (bd) & \underline{(be)} \\ & & \underline{(cd)} & (ce) \\ & & & \underline{(de)} \end{array}$$

We observe in the first place that the joint connecting any two links is the center for the relative motion of those links; thus, the motion of the gear b relative to the frame a is a rotation about the point (ab), which is the center of the journal; the motion of the link d relative to the link e must be a rotation about the joint (de) that connects them. We find, therefore, the five centers (ab), (ac), (cd), (de), and (be) by simple inspection. Furthermore, the instantaneous center of the relative motion of the gears b and c is their point of contact (bc); that is, if we consider the gear b as stationary, every point of the gear c is rotating about the point of contact as a sort of fulcrum.

We have now to find the unknown centers (ad), (bd), (ae), and (ce) by drawing straight lines. Consider first the center (bd), which involves the two links b and d. By adding another link c, we get a system of three links b, c, and d, with the three centers (bc), (cd), and (bd), which we know must lie in the same straight line. Therefore, we draw through the known centers (bc) and (cd) a straight line. Somewhere on this line lies the unknown center (bd). In the same way we combine with the links b and d the third link e, forming a system of three centers (be), (de), and (bd). The unknown center (bd) must lie in the straight line connecting the known centers (be) and (de); therefore, since (bd) lies in both lines (bc)-(cd) and (be)-(de), it must lie at their intersection. We may express this fact by the following arrangement:

$$(bd)\begin{cases}(bc)\text{-}(cd)\\(be)\text{-}(de)\end{cases}$$

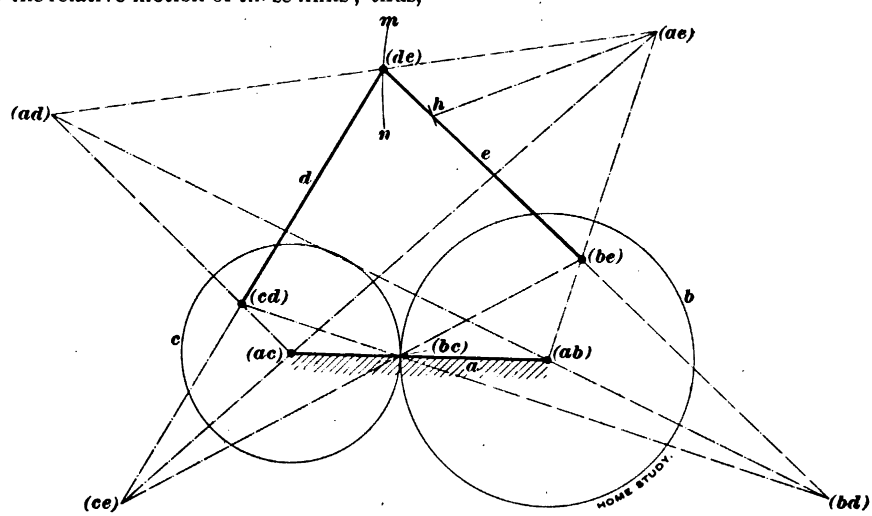

FIG. 2.

For the location of the center (ce), we have the following combination:

$$(ce)\begin{cases}(bc)\text{-}(be)\\(cd)\text{-}(de)\end{cases}$$

By combining the links b and d successively with the two links c and e, we obtain the two systems (bc), (be), (ce) and (cd), (de), (ce). The unknown center, therefore, lies at the intersection of the lines (bc)-(be) and (cd)-(de). The two remaining centers are readily found from the combinations

$$(ad)\begin{cases}(ab)\text{-}(bd)\\(ac)\text{-}(cd)\end{cases} \text{and } (ae)\begin{cases}(ab)\text{-}(be)\\(ac)\text{-}(ce)\end{cases}$$

the constructions being clearly shown in the figure. It will be noticed that a straight line through the center (ad) and (ae) last found must past through the known center (de); this furnishes a check on the accuracy of the work.

We will at this point briefly indicate the use of the instantaneous center in the study of the motions of a mechanism. We have supposed that in the mechanism of Fig. 2 the link a is fixed or stationary; then, any center containing the letter a is a center of the motion of some link relative to the stationary link a. For example, the motion of the link e is a rotation about the point $(a\,e)$ just as truly as the motion of the gear b is a rotation about the permanent center $(a\,b)$. For this instant every point of the link e is rotating about the point $(a\,e)$. The direction of the motion of any point, as h, is perpendicular to the line h-$(a\,e)$ joining the point to the center. Furthermore, the velocities of points in a rotating body are proportional to their distances from the center of rotation. Suppose we know the velocity of the end $(b\,e)$ of the link e; then, we can find the velocity of the other end $(d\,e)$ by the proportion

$$\frac{\text{vel. } (d\,e)}{\text{vel. } (b\,e)} = \frac{\text{distance } (d\,e)\text{-}(a\,e)}{\text{distance } (b\,e)\text{-}(a\,e)}.$$

By means of the various centers we are enabled to find the velocity and direction of motions of any kind of a moving link. This application of the instantaneous center will be fully treated in a subsequent article.

The mechanism shown in Fig. 1 has various applications in practice. If the gears have equal diameters, and the links d and e are equal, the point $(d\,e)$ will move in a straight line, provided the points $(b\,e)$ and $(c\,d)$ are so located that the lines $(a\,c)$-$(c\,d)$ and $(a\,b)$-$(b\,e)$ lie on the same side of $(a\,b)$-$(a\,c)$ and make equal angles with it. The path of the point $(d\,e)$ in Fig. 2 is the curve $m\,n$.

If some of the links of a mechanism have a motion of translation relative to the fixed link or to some other link, the corresponding centers will lie at an infinite distance. (See Plane Motion, Part I.) This fact, however, in no way complicates the problem of finding the unknown centers. The mechanism shown in Fig. 3 is an example of such a case. It is composed of four links, of which the frame a is fixed. The crank b rotates about the center $(a\,b)$ and gives a vibrating motion to the link d. The block c slides in a slot in the link d; therefore, the instantaneous center of the relative motion of c and d lies at an infinite distance in a line perpendicular to the direction of the sliding. The centers $(a\,b)$, $(a\,d)$, and $(b\,c)$ are known, they being the joints connecting adjacent links.

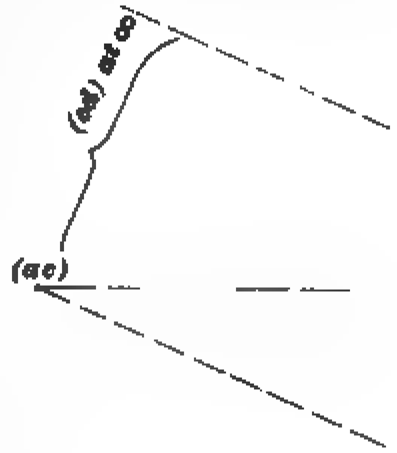

FIG. 3.

To find the unknown instantaneous center $(b\,d)$, we have the combination,

$$(bd)\begin{cases}(ab)\text{-}(ad)\\(bc)\text{-}(cd)\end{cases}$$

That is, $(b\,d)$ lies at the intersection of the lines $(a\,b)$-$(a\,d)$ and $(b\,c)$-$(c\,d)$. The first line is readily drawn, as the centers (ab) and (ad) are known; the second line joins the known center $(b\,c)$ to the center $(c\,d)$, which lies at an infinite distance. We cannot, of course, draw a line to an infinitely distant point, and in this case we are not required to do so. We have merely to draw a line through $(b\,c)$ in the direction of the infinite point $(c\,d)$; as we have seen, the direction is perpendicular to the direction of the motion of the link c, relative to d. Therefore, a line drawn through (bc) perpendicular to the direction in which c is sliding, cuts the line $(a\,b)$-$(a\,d)$ in a point which is the desired center $(b\,d)$.

The center $(a\,c)$ is located from the combination:

$$(a\,c)\begin{cases}(a\,b)\text{-}(b\,c)\\(a\,d)\text{-}(c\,d)\end{cases}$$

As before, we draw through $(a\,d)$ a line in the direction of the infinitely distant point $(c\,d)$, that is, perpendicular to the direction in which c is sliding. The intersection of this line with the line passing through the centers $(a\,b)$ and $(b\,c)$ is the instantaneous center $(a\,c)$.

A QUESTION IN PERSPECTIVE.

A. Langerfeld.

THE HORIZON LINE—POINT OF SIGHT—VANISHING POINTS, ACCESSIBLE AND INACCESSIBLE.

What is the simplest way of making a perspective drawing from the enclosed sketch? I believe there is a method by which a perspective drawing can be made on a very small board, the vanishing points being found indirectly.

The answer to this question—sent in by a subscriber—is too long to be published in the Answers to Inquiries columns, but, as it will probably interest a large number of our readers, we insert it here.

Make first a faint, freehand sketch of the monument, showing approximately (see Fig. 2), the size and position of the perspective drawing wanted. Draw a vertical center line $a\,b$ through the middle of the sketch. Draw a horizontal base line $c\,d$ perpendicular to the center line $a\,b$ through the lowest point e of the sketch. Draw $f\,g$ parallel to $c\,d$, locating it at that position in the sketch where all lines which are in reality level are horizontal in the sketch. This is the *horizon line* and must be drawn as high above $c\,d$ as the eyes of the person who is looking at the object are assumed to be. All vanishing points of level lines are on this horizon line. The intersection a is the *point of sight*. Using a straightedge, draw the base line $e\,h$ over the sketched base line, meeting the horizon line in g. This point g is the vanishing point of all edges parallel to $e\,h$. Draw a straight line over the sketched base line $e\,i$, meeting the horizon, if convenient. This meeting point is generally, as in the present case, too far away to come within the limits of a small board. Instead of this vanishing point, a vertical line $j\,f$ may be used. This line is found in the following manner: Draw the vertical line $e\,e'$ through e, intersecting $f\,g$ in e'. Bisect $e\,e'$ in k and draw a parallel to $e\,i$ through k, meeting $f\,g$ in f. In case f does not fall within the limits of the paper, a smaller part of $e\,e'$ may be taken from e' down (preferably a quarter). Draw a vertical line $f\,j$, intersecting $e\,i$ continued, in j. Next, the *standpoint* n must be found: Draw a parallel to $e\,h$ through k, meeting $f\,g$ in l. Make $g\,m$ equal to $l\,f$ (unless $e'\,k$ was made one quarter of $e'\,e$, then make $g\,m$ equal to twice $l\,f$) and make $m\,n$ equal to $m\,g$. The point n is the standpoint, and $n\,a$ is the distance at which the perspective view is taken, in order that it shall appear about like the first rough sketch. Draw $o\,p$ parallel to $f\,g$, a short distance above the top of the sketch and intersecting the center line $a\,b$ in a', and $e\,e'$ in e''. The line $o\,p$ represents the plane of the picture seen on edge from above, and a plan A of the object must be drawn behind this plane, or (looking at the drawing) above the line $o\,p$. The required position of the plan A is found as follows: Through e'' draw $e''\,h'$ parallel to a line through n and g, and make $e''\,h'$ equal to the given width of the plinth—in this case 3′ 4″—to a scale of, say, $\frac{1}{2}$ inch = 1 foot. Draw $e''\,i'$ at right angles to $e''\,h'$, and make $e''\,i'$ equal to the front of the plinth, 5′ 3″, to the same scale. The angle $h'\,e''\,i'$ represents the front part of the plan of the plinth. Draw the center line $v\,q$ parallel to $e''\,i'$ and bisecting $e''\,h'$. The remainder of the plan A is added as wanted. Make $a'\,n'$ equal to $a\,n$, and draw lines from all exposed points in the plan to n', intersecting $o\,p$ in i'', 6_1, etc. Draw vertical lines from these points of intersection into the perspective B where wanted. To find the perspective heights of points on these vertical lines, proceed as follows: Make $a'\,b'$ equal to $a\,b$, and draw $b'\,t$ perpendicular to $b'\,a'$. Extend $e\,e''$ above $o\,p$ to r intersecting the lines of the plan, as shown. Through these intersections draw parallels to $o\,p$ intersecting $b'\,t$. Number the points in the plan A which are to be shown in the perspective B, and place the same numbers on the corresponding intersections on $b'\,t$, in C. As point *1* is on the plane of the picture, its height above $c\,d$ is

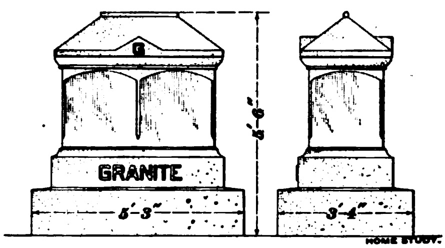

FIG. 1.

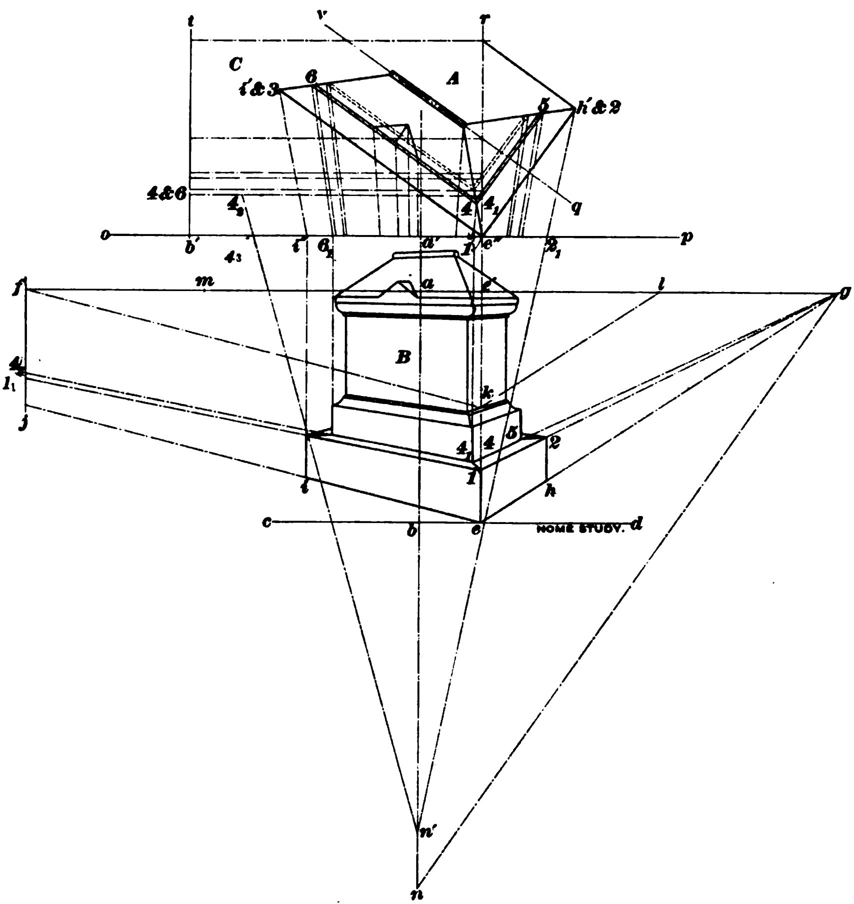

FIG. 2.

the same in the perspective B as in the projection drawing C, which is a sectional elevation; therefore, e-1 in B is made equal to the given height of the plinth, and, by drawing 1-g, in B, the correct perspective of the top of the plinth is obtained on this side. The perspective of the rear corner, 2, B, is found by drawing 2-n' from 2 in A, intersecting op in 2_1 and then drawing a vertical line down from 2_1 on op to h. The front corner 4 in A, of the bottom of the socket or base just above the plinth, is found by drawing a parallel to op from the intersection 4_1 of the line 4-5 with $e''r$ to $b't$, then setting off the height of this point from 4 on $b't$ to 4_2. Draw 4_2-n' intersecting op in 4_3. Set off b'-4_3 on ee' from e up to 4, B. Draw g-4, in B; then draw n'-4, A, intersecting op, and from this intersection draw a vertical line to g-4, B, continued, intersecting it in 4_1, which is the perspective of 4, A. To find the perspective of the line 4-6, A, continue 6-4, A, to intersect $e''r$, and transfer this point to op as before by drawing a parallel to op intersecting $b't$, setting off its height thereon from $b't$ and drawing a line to n'. The point thus found on op will be nearer to b' than 4_3. Bisect its distance from b', and make j-4_2 equal to the half so found; then draw 4_1-4_2, B. All the other points and lines are found in a similar manner; thus, $j\,1_1$ is one-half of e-1. In case the desired position of the plan A in reference to the front line or plane of the picture op, and the distance $a'n'$ of the standpoint n' from op are given, then it is not necessary to begin by making a freehand sketch, and the perspective may be found by first drawing the plan A and locating the vanishing points g etc. by drawing a parallel to $e''h'$, A, through n.

DESIGNING OF A PIN JOINT.

Carl G. Barth.

THE WORK OF A CARELESS OR INEXPERIENCED MAN COMPARED WITH THAT OF A CAREFUL AND INTELLIGENT DESIGNER.

AN ordinary pin joint furnishes an excellent opportunity to point out the difference between the manner in which a careless or inexperienced designer, and a careful, experienced one, will analyze the stresses of a structure, and then proportion its parts.

Referring to the joint shown in Fig. 1, it is immediately realized—common sense alone reveals the fact—that the pin is in shear at the two sections marked A, the shearing force at each section being equal to one-half the total pull P on the joint. Now, the careless designer, on seeing this, jumps to the conclusion that all he has to do is to make the diameter D of the pin such that this shearing force will be safely withstood; and this he does by forming the equation $\frac{D^2\pi}{4} \times S_s = \frac{1}{2}P$, which, when solved for D, gives

$$D = \sqrt{\frac{2P}{\pi S_s}}, \qquad (1)$$

in which S_s is the permissible shearing stress for the material of the pin. If the diameter d of the rods connected by the joint is properly proportioned for the pull P, then

$$P = \frac{d^2\pi}{4} S_t, \qquad (2)$$

in which equation S_t is the permissible tensile stress in the material of the rods.

FIG. 1.

Substituting this value of P in formula (1), we get

$$D = \sqrt{\frac{2}{\pi} \times \frac{\frac{d^2\pi}{4} S_t}{S_s}} = \sqrt{\frac{S_t}{2S_s}} \times d.$$

If the pin is of the same material as the rods, S_s may be taken equal to $.8\,S_t$, when this formula reduces to

$$D = \sqrt{\frac{S_t}{2 \times .8\,S_t}} \times d = .7905\,d, \text{ say } .8\,d. \qquad (3)$$

The careless designer, having thus determined the diameter of the pin, proceeds to calculate the thickness of the eyes of the fork, on the supposition that the compressive stress produced in each eye is uniformly distributed over its length.

The *total* pressure in each eye is, of course, $\frac{1}{2}P$, and, as the *projected* area of the eye is $D \times t$, he writes the equation

$$D \times t \times S_c = \frac{1}{2}P,$$

in which S_c is the permissible compressive stress per square inch of *projected* area between the pin and the eye.

Substituting the value of D from (3), and the value of P from (2), this equation becomes

$$.8\,d\,t\,S_c = \frac{1}{2} \times \frac{d^2\pi}{4} S_t,$$

which, solved for t, gives

$$t = \frac{\pi}{.8 \times 2 \times 4} \frac{S_t}{S_c} \times d = .491 \frac{S_t}{S_c}\,d.$$

Taking S_c equal to $\frac{2}{3}$ of S_t, this gives

$$t = \frac{3}{4}\,d, \text{ about.} \qquad (4)$$

Then he finishes the design, the result being as depicted in Fig. 2, and feels satisfied that it is all that could be desired.

Now, let us see how the careful and experienced designer goes about the same work. He too is immediately aware that the pin is in shear at sections A, but he also realizes that there are certain bending stresses to be taken care of. Thus, as the pin is subjected to compressive stresses in the eyes of the fork as indicated in Fig. 3, and to opposing compressive stresses *between* the eyes; the result is that the pin as a whole is subjected to a bending moment; which bending moment, at the center section of the pin, may be written thus:

$$\frac{1}{2}P(a-b) = \frac{1}{2}P(1\tfrac{1}{8}\,d - \tfrac{5}{8}\,d) = \frac{1}{4}P \times \frac{3}{4}\,d = \frac{3}{16}P\,d = \frac{3}{16}\frac{d^2\pi}{4}S_t\,d = \frac{3\pi}{64}S_t\,d^3.$$

Denoting the maximum stress produced

by this moment by S, the resisting moment of the pin will be

$$\frac{\pi}{32} D^3 S = \frac{\pi}{32} (.8\,d)^3 S = .016\,\pi S d^3,$$

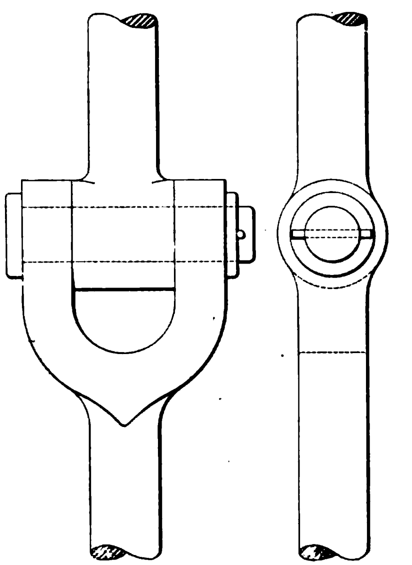

FIG. 2.

and, putting this equal to the bending moment, we get

$$.016\,\pi S d^3 = \frac{3\pi}{64} S_t d^3,$$

which, solved for S, gives

$$S = \frac{3}{.016 \times 64} S_t = 2.93\,S_t.$$

That is to say, the maximum bending stress in the pin would be nearly three times greater than the direct stress in the rods.

But, of course, under this heavy stress the pin would bend materially, and take a form like that shown in an exaggerated manner

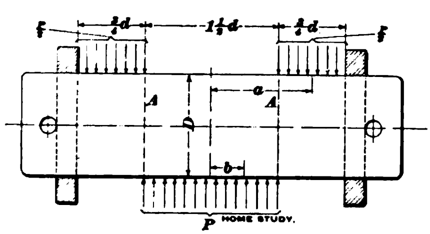

FIG. 3.

by Fig. 4, and would then be unable to maintain a uniformly distributed pressure, both in the eyes of the forked rod and in the eye of the straight rod, the pressures necessarily concentrating towards the sections A and A, as indicated on the figure.

However, with this concentration of the pressures, the bending moment on the pin would not be so great as figured above on the supposition of uniform distribution, and so the actual amount of bending of the pin would also be less, with a consequent lesser concentration of the pressures, and so on indefinitely.

We thus see that, on the one hand, we cannot have uniform distribution of pressure between the pin and the eyes, while, on the other hand, we cannot have so much concentration of pressure as would correspond to as much bending of the pin as would be produced by such uniform distribution. However, as the wear will be greatest where the pressure is greatest, the wear will tend to establish a condition under which there will be uniform distribution of pressure between the eyes and the pin, in spite of the greater bending produced.

For this reason a careful designer will so proportion a pin joint that the pin will be amply strong to resist the bending moment produced by such uniform distribution of the pressures upon it, whereby it will also

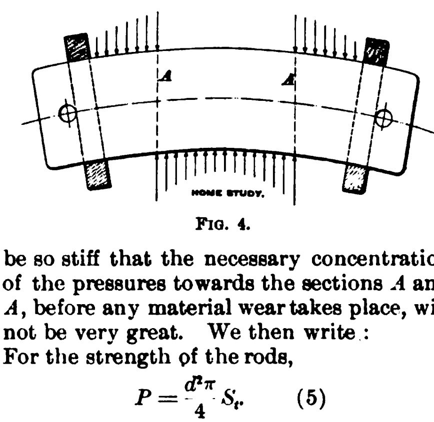

FIG. 4.

be so stiff that the necessary concentration of the pressures towards the sections A and A, before any material wear takes place, will not be very great. We then write:

For the strength of the rods,

$$P = \frac{d^2\pi}{4} S_t. \qquad (5)$$

For the pressure in each eye of the forked rod,

$$\tfrac{1}{2} P = D\,t\,S_c. \qquad (6)$$

For the bending moment on the pin,

$$\tfrac{1}{2} P(a-b) = \tfrac{1}{2} P\,t,$$

which must equal its resisting moment,

$$\frac{\pi}{32} D^3 S,$$

so that we get

$$\frac{1}{2} P t = \frac{\pi}{32} D^3 S. \qquad (7)$$

If for equal material of the pin and the

rods we put $S = S_t$, and also substitute the value of $\frac{1}{2} P$ as given by (6), we get

$$D t S_c t = \frac{\pi}{32} D^2 S_t,$$

which, solved for t, gives

$$t = \sqrt{\frac{\pi}{32} \frac{S_t}{S_c}} D = \frac{1}{4} \sqrt{\frac{\pi}{2} \frac{S_t}{S_c}} D. \qquad (8)$$

Equating the values of P as given by (5) and (6), we get

$$\frac{d^2 \pi}{4} S_t = 2 D t S_c,$$

which, solved for t, gives

$$t = \frac{\pi}{8} \frac{S_t}{S_c} \frac{d^2}{D} = \frac{1}{4} \times \frac{\pi}{2} \frac{S_t}{S_c} \frac{d^2}{D}. \qquad (9)$$

Equating the values of t as given by (8) and (9), we get

$$\frac{1}{4} \sqrt{\frac{\pi}{2} \frac{S_t}{S_c}} D = \frac{1}{4} \frac{\pi}{2} \frac{S_t}{S_c} \frac{d^2}{D},$$

which, solved for D, gives

$$D^2 = \sqrt{\frac{\pi}{2} \frac{S_t}{S_c}} d^2, \text{ or } D = \sqrt[4]{\frac{\pi}{2} \frac{S_t}{S_c}} d. \qquad (10)$$

Assuming $S_c = \frac{1}{2} S_t$, this becomes

$$D = \sqrt[4]{\frac{\pi}{2} \frac{S_t}{\frac{1}{2} S_t}} d =$$

$$\sqrt[4]{\pi} d = \frac{4}{3} d, \text{ approximately.} \qquad (11)$$

Substituting in (8), we get

$$t = \frac{1}{4} \sqrt{\frac{\pi}{2} \frac{S_t}{\frac{1}{2} S_t}} \times \sqrt[4]{\pi} d =$$

$$\frac{1}{4} \sqrt[4]{\pi^3} d = .6 d, \text{ approximately.} \qquad (12)$$

The joint shown in Fig. 2 has a pin proportioned by formulas (3) and (4); that shown in Fig. 5, one proportioned by formulas (11) and (12).

In Fig. 2 no regard has been paid to the bending stresses in either the arms of the fork or in their eyes—after the fashion of a careless or inexperienced designer—while in Fig. 5 due regard has as far as possible been paid to these stresses, with a view to getting these parts of approximately uniform strength throughout.

However, we cannot here go into the considerations of these parts, but simply call

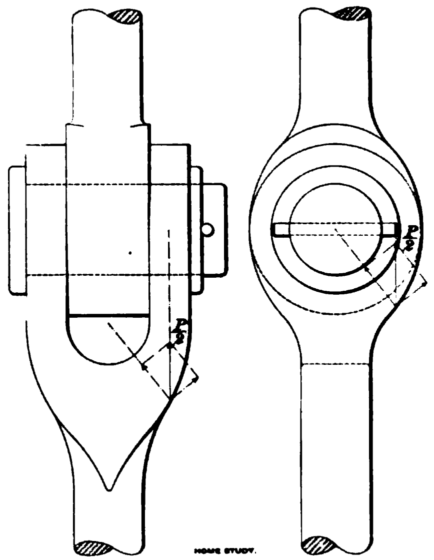

FIG. 5.

attention to them in order to put the would-be designer on his guard. The design shown is somewhat *ideal*, but is shown so purposely in order to impress the reader with the difference between what is bad and what is good in a simple device of this nature.

A SIMPLE AIR COMPRESSOR.

C. P. Turner.

A NOVEL APPLICATION OF AN OLD PRINCIPLE—EFFECT OF A RAPID CURRENT OF A FLUID WHEN IT PASSES THROUGH OR AROUND ANOTHER FLUID.

THE Taylor hydraulic air compressor is an interesting application of an old and well known principle that has long been applied to a variety of purposes. This principle is the tendency of a current of any gas or liquid, flowing through or around another fluid, to carry the surrounding fluid along with it. A mixture of the two will thus be formed, which, if the strength of the current is great enough, will be carried along through any tube or closed channel that may be provided for their passage.

The application of this principle to the injector,* the jet pump, the steam blower, and similar devices—where a current of

* See HOME STUDY MAGAZINE for September, 1896, for a description of the action of the injector.

steam flowing from a nozzle with a high velocity is made to propel water or air from a chamber surrounding the jet through a pipe leading to the required point of discharge—is familiar to all machinists and engineers. We will now show two applications of the same principle to devices that, while they are not quite

FIG. 1.

in Fig. 1 and called a *trompe*. Here we have a jet of water flowing down through the conical nozzle *b* from the sluice *a* into the pipe *c*. The jet, in its passage through the pipe, carries the surrounding air with it, thus drawing a steady current of air in through the holes *d* and carrying it down into the chest *e*. The water settles to the bottom of this chest and flows out through the hole *i*, while the air rises to the upper part and from there is forced out through the pipe *f* and the nozzle *g* into the fire on the hearth *h*. This device, while very simple and cheap, was not capable of furnishing a high pressure of blast, and never reached a high degree of efficiency in the use of the falling water, the best efficiency obtained, according to good authorities, being not more than 15 per cent. For these reasons its use has always been limited to periods and districts where only the most simple mechanical devices could be obtained.

Another and more modern application of this principle is seen in the Bulkley "injector" condenser, which is shown in Fig. 2. In this case, the work to be done, instead of taking air from the surrounding atmosphere and delivering it at an increased pressure in a closed vessel, is to remove the air and vapor from a closed space and deliver it into an open vessel against the pressure of the atmosphere; at the same time, the water that is employed in removing the air and vapor from the exhaust pipes serves also to cool and condense the exhaust steam.

In Fig. 2, which shows the condenser attached to a Corliss engine, the exhaust steam passes from the cylinder through the pipe *a* to the top of the condenser. Water from a pump, or other source of supply, enters the condenser through the pipe *b*, surrounds the conical exhaust inlet *c*, and flows downward around the lower edge of this inlet in a thin stream. The exhaust steam from *c* is condensed by coming in contact with this stream of water, and at the same time any air that may have entered the cylinder

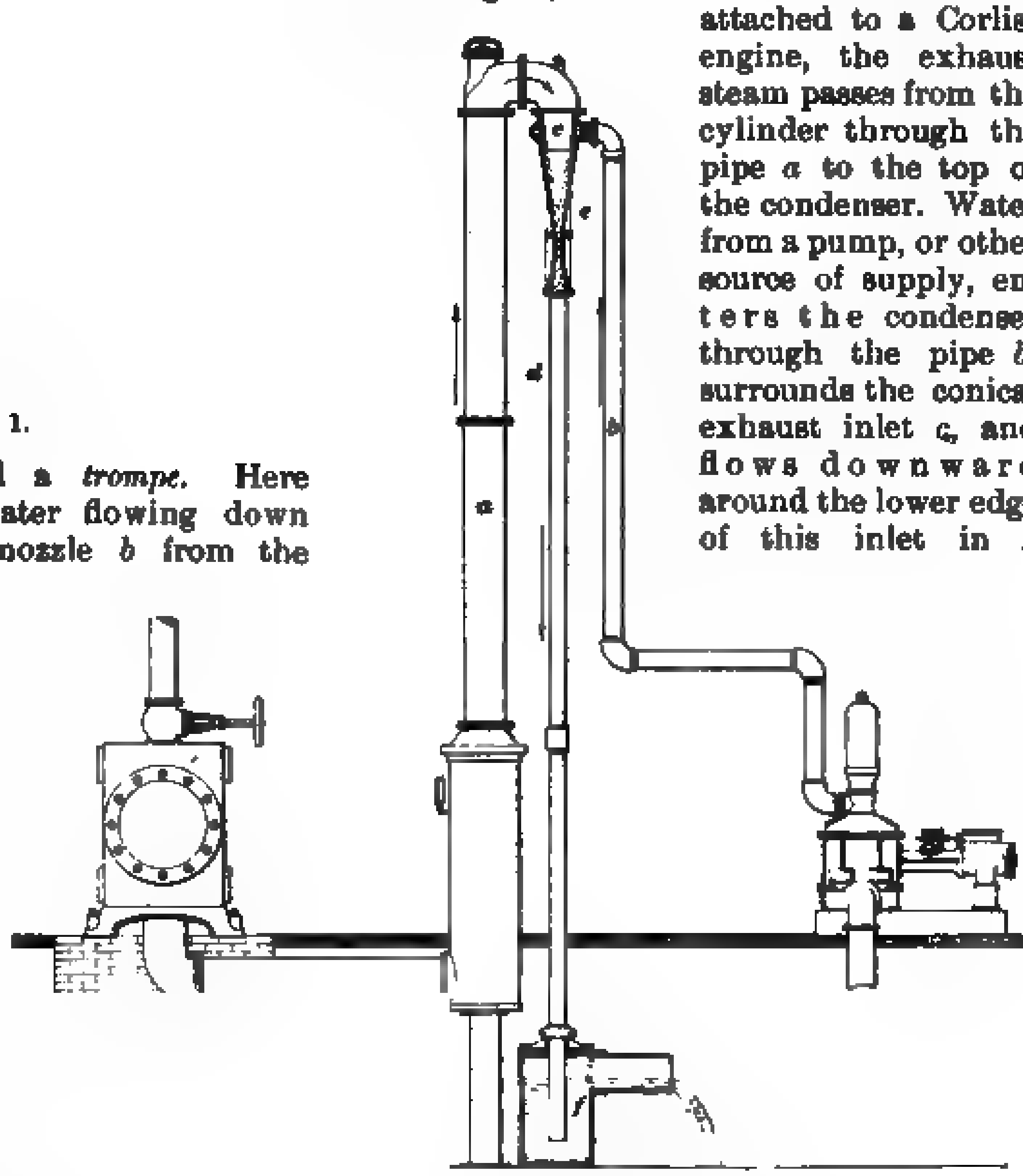

FIG. 2.

or exhaust pipe, and any uncondensed vapor, are caught by the downward current of water, and carried through the discharge pipe *d* into the hotwell *f* below. The lower end of the discharge pipe dips below the surface of the water in the hotwell, so as to prevent any return of air through it when the condenser is not working, or when the quantity of water flowing through it is insufficient to keep the pipe filled.

In order to obtain a good vacuum, it is necessary to make the length of the discharge pipe great enough to provide a column of water whose weight will balance the pressure of the atmosphere; that is, the condensing tube *e* must be placed at least 34 feet above the surface of the water in the hotwell.

Coming now to the Taylor hydraulic air compressor, we find the principles illustrated above extended so as to utilize the fall of large quantities of water in compressing air to a pressure great enough to make it available in driving air-pressure engines and pneumatic machinery of all classes. A deep well, or shaft *a*, Fig. 3, is dug in the vicinity of the stream below the fall, and a large tank *b*, called the *compression* tank, is placed at the bottom of the shaft. The compression tank, which is closed at the top and open at the bottom, is so placed that there is a space between the bottom edge and the bottom of the shaft, as shown in the figure. A tube *x x* connects with the compression tank, and rises vertically to a level, a little below the surface of the water in a receiving tank *d*, which is supplied through a penstock, or flume *e*, leading from the stream above the fall. The upper end of the tube *x x* is slightly enlarged, and is fitted with an air-inlet pipe *f*, which leads from a point above the surface of the water in the receiving tank, down into the upper end of the tube. Water flows from the receiving tank into the upper end of the tube, and flows downwards past the end of the air-inlet pipe; air is drawn in through the pipe *f* by the downward current of water, and is carried with the water into the compression tank. Here the velocity of the current of water and air is checked, thus allowing the air to separate from the water and rise to the top of the tank, while the water is forced out below the bottom edge, rises through the shaft, and finally flows away through the channel of the stream below the falls. As will be readily seen by an inspection of the figure, the air in the compression tank is subjected to a pressure proportional to its depth below the surface of the water in the overflow channel *g*, and it is thus compressed to a degree depending on the depth of the shaft.

Since a head of water equal to a depth of 1 foot produces a pressure of .434 pound per square inch, we see that in order to get air at a given pressure—say 60 pounds per square inch—the shaft must be deep enough

FIG. 3.

to bring the air in the compression tank 60 ÷ .434 — about 138 feet below the surface of the water in the overflow channel.

A pipe *h* leads the air from the compression tank to the mill or mine where it is to be used.

The quantity of air that will be furnished by this device depends on the height of the fall, the quantity of water that can be used, and the construction of the air and water inlets. As has been said, the efficiency of the old trompe for furnishing a blast was very low, and the pressures obtained were small; consequently, it has generally been replaced by some form of blower, driven by

a waterwheel or other power; the makers of the Taylor compressor, however, claim a good efficiency for their apparatus, and, as has been seen, the pressure obtained may be made as great as desired by making the shaft sufficiently deep. Some of its apparent advantages, as a method of utilizing a fall of water for producing a supply of compressed air, are its simplicity of construction, which should make the cost of operation and maintenance small, and the fact that the air, while being compressed, is in such close contact with water that the heat developed during its compression is at once absorbed by the water, thus allowing the compression to take place at a practically constant temperature, and reducing, to a considerable extent, the work required to compress a given quantity of air.

HOW TO READ A MECHANICAL DRAWING.*

G. Herbert Follows.

A Seemingly Impossible Riddle Promptly Solved by Any One Who Understands the Language of Mechanical Drawing—The True Value of Projection Lines.

LAST month we spoke of mechanical drawing as a language, and discussed what we called its alphabet. A projection line was shown to be an imaginary line passing through, and at right angles to, an imaginary plane, situated between the eye and an observed body. We shall presently discover the true value of the projection line in mechanical drawing.

The following riddle is often asked and as often puzzles the victim: "What is the shape of the body that will fit either a round, square, or triangular hole?" On the spur of the moment one is rather inclined to say that such a body is impossible. A proper use of the language of mechanical drawing, however, will enable us to solve the riddle. The body must fit either a round, square, or triangular hole; construct, then, a circle, a square, and a triangle; arrange them as in Fig. 1, and what do we learn? We learn that a body whose plan is a circle, whose side view is a square, and whose end view is a triangle, fulfils all the conditions. What does such a body look like? Fig. 2 is a perspective drawing of it, and Fig. 3 shows that the projections of it are precisely similar to those shown in Fig. 1. Here we have an example of a very simple body, which it would be difficult to represent to the patternmaker or machinist without the aid of a mechanical drawing. Three views of it are necessary, in order to show that the plan is circular, the side view square, and the end view triangular.

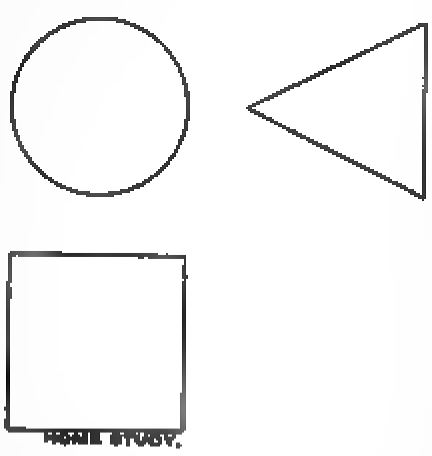

Fig. 1.

Now let us deal with the casting shown in Fig. 4. This representation of it would be of no use in the pattern shop; it would be impossible, even with the aid of a written description, to make it of real practical use. The mechanical drawing, however, of Fig. 5 tells the whole story without the aid of either verbal or written explanation. To make clear the meaning of each view of this mechanical drawing, we will deal with the casting much as we did with the prism last month; in other words, we will place it behind transparent planes, and view it from the positions indicated by the groups of eyes in Fig 6. We make use, as before, of the three plates X, Y, and Z, but, in order to look straight at the inclined side of the casting, we introduce a fourth plate W, which we make parallel to the inclined side, and at right angles to the top plate X. There is probably no need to explain the reason for doing this. If you want to see the shape of anything you naturally stand in front of it.

Fig. 2.

Now, if the plates Y, W, and Z are swung up about their hinges, we get what is shown in Fig. 7; and this is precisely what we

* *Begun in the May Number.*

already know to be a mechanical drawing of the casting.

Remembering that the views as drawn on the plates *X*, *Y*, *Z*, and *W* are projections of the shape of the casting as viewed from immediately in front of the respective plates, and that the imaginary lines from the eye, in its various positions, to the casting are projection lines, we find that the mechanical drawing is simply a plan of the views in Fig. 6 after they are swung up into the horizontal, as shown in Fig. 7, and that the

FIG. 3.

projection lines of Fig. 6 become, in plan, as shown in Fig. 5. A good machine designer never forgets this, nor does he ever lose sight of the *solidarity* of the object he is representing. If he is designing a casting, such, for instance, as that shown in Fig. 4, he first forms a mental picture of the general proportions of the completed piece, not trusting to making important discoveries as he goes along, but leaving only the details to be worked out in the actual drawing. In this way he makes intelligent use of projection lines, and is free to interpose any number of imaginary planes, such as *W* in

FIG. 4.

Fig. 6, through which to view the object. Fig. 8 is an attempt to show how simple and natural is the growth of the mechanical drawing from the object represented. We have chosen the case of the symmetrical prism, because two views of it are sufficient to work by, and the illustration is thereby simplified. We have first the prism itself, then the actual projections of it upon the

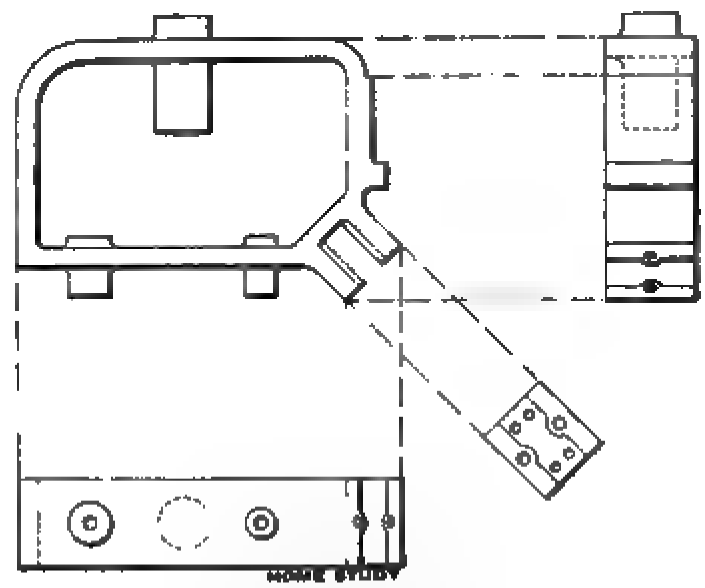

FIG. 5.

glass plates *X* and *Z*, and finally, after the plate *Z* has been swung up level with *X*,

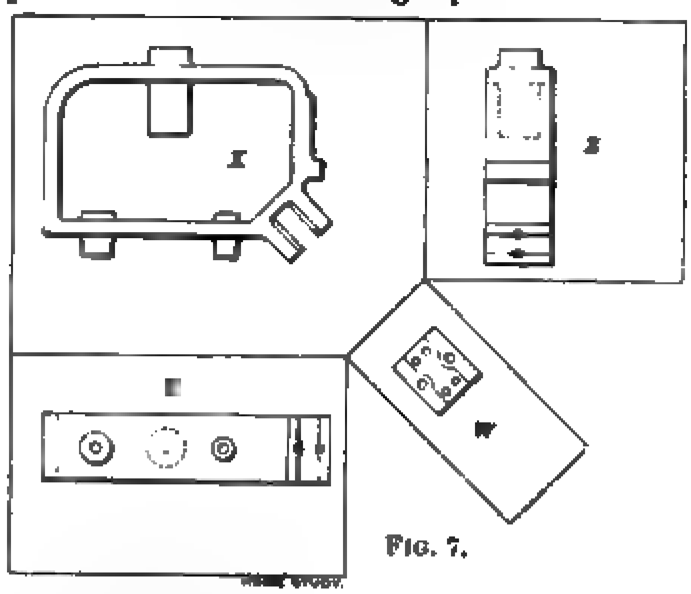

FIG. 7.

the mechanical drawing, as a *plan* of the projections.

A projection line is thus seen to be the

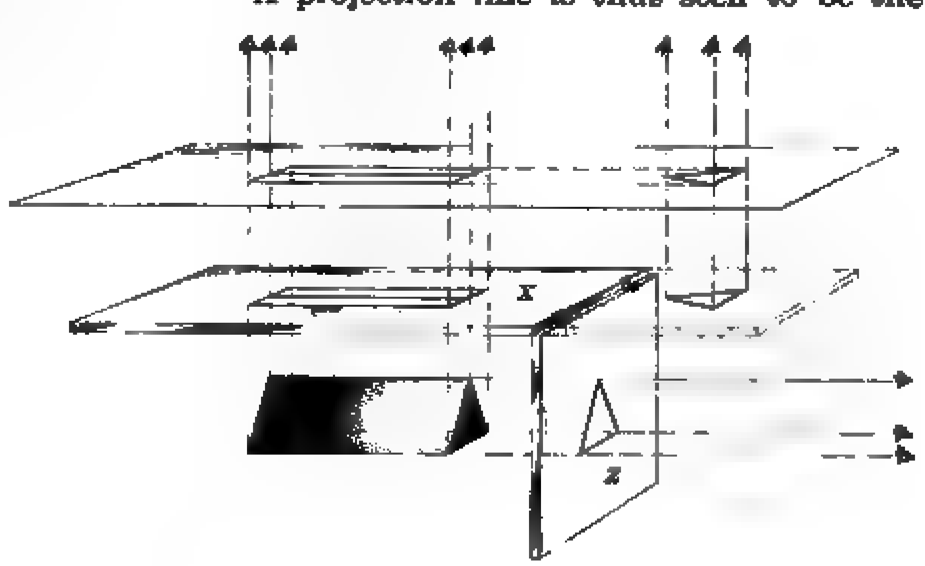

FIG. 8.

plan of an imaginary *line of sight*. It is valuable because it enables us to make a mechanical drawing of an object without the aid either of glass projection plates or of the object itself. It also indicates to others

the direction from which the draftsman imagined he was looking at the object when he made the drawing, so that the mental picture formed by the *reader* of the drawing is identically the same as that possessed by the draftsman who *made* the drawing.

Next month we shall take up the subject of sectional views, and the article will be brought to a close by a demonstration of the fact that a mechanical drawing may consist of many views arranged as best suits the fancy of the draftsman, but that the key to quick and intelligent reading of *any* arrangement of views is a full understanding and appreciation of what we have chosen to call the *alphabet of the language of mechanical drawing*.

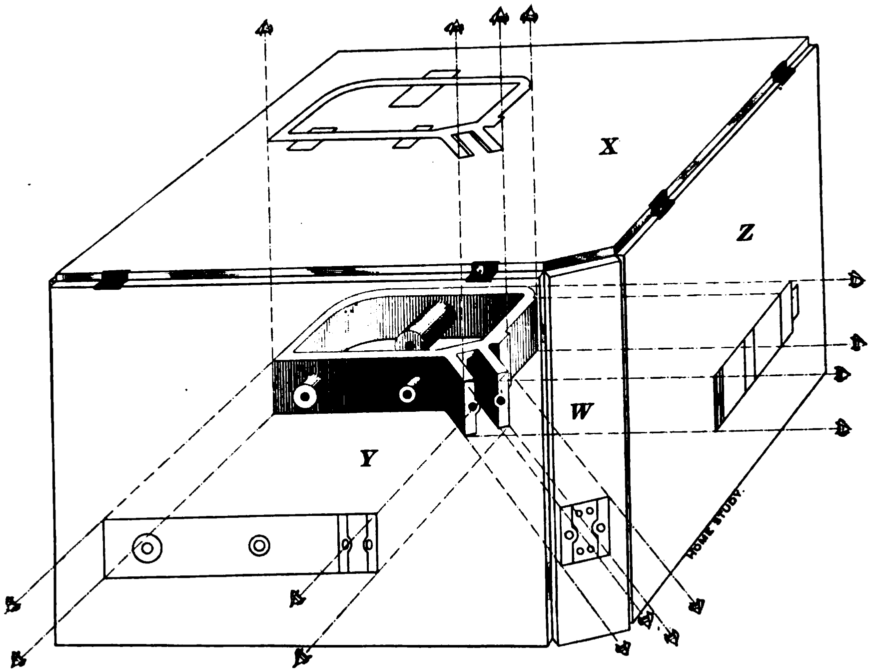

FIG. 6.

(*To be Continued.*)

A PIECE OF PIE.

NOT long since a New York paper offered a prize for the solution of the following puzzle:

"How many pieces can be made by dividing a pie with seven straight cuts of a knife?"

At a first glance the puzzle seems a hard one to answer, but a little thought will show that to get the maximum number of pieces, one needs but to observe the following rule:

Be sure that each successive cut crosses every previous one and at some point that is not the intersection of two previous cuts.

It will then be found that seven straight cuts will give just 29 pieces of various sizes and shapes.

As an interesting problem the writer sought an algebraic formula to cover any similar case of pie division. It was easily deduced and is as follows.

If P is equal to the maximum number of pieces that can be obtained with n straight cuts of the knife, then $P = n\left(\frac{n+1}{2}\right) + 1$.

From this formula we can construct a table and we find that 6 cuts give 22 pieces; 8 cuts 37 pieces; 9 cuts 46 pieces, and so on. So much for mathematics, a piece of pie and a knife.

FOSSIL BIG TREES.

Arthur Lakes.

PROCESS OF PETRIFACTION—HOW VEGETABLE OR ANIMAL TISSUES ARE REPLACED BY STONE.

MOST of our readers are probably familiar with the "big trees of California"—the *Sequoia gigantia*. Many, doubtless, have seen them, and stood in awe before these giants of creation. Few, however, have seen or even thought of them as sometimes turned into stone. Last summer in a little park called Florissant, 9,000 feet above the sea and in the heart of the Colorado range of mountains, we came across half a dozen stumps of these trees, from ten to fifteen feet in diameter, all of them within a square acre, and all turned into solid, hard stone. One stump in particular had been partially excavated from its bed by some enterprising parties, with a view to carrying it to the World's fair. It stood twenty feet upright and was fifteen feet in diameter. As they could not carry it away bodily, they tried to saw it up in sections; but, fortunately for Colorado, the hard quartz composing it was more than a match for their stone saws, and the saws are still sticking in the tree as monuments to man's discomfiture.

So wonderfully had the stony material replaced the texture and grain of the original tree, and, in some parts, even simulated its reddish color, that, but for its unusual size, any one might have passed it by as an old dead pine stump, felled by some early settler. A Californian, however, would at once have recognized it, by the peculiar appearance and texture of the wood, as a fossil representative of his native redwood. Not only is the rough texture of portions of the thick bark preserved, but even the minute wood cells and annual rings of growth are retained. Here and there a little oxide of iron gives it somewhat the red tinge of the modern redwood, but the prevailing color is an ashen grey, like that of any old dead stump. As you pick up chips, scattered around by the hammers of tourists, their weight and hardness alone convince you that they are really stone and not pine chips left by the axe of an old-time woodsman. To complete the illusion and resemblance to the living tree, sap vessels and veins are here and there filled with what appears to be gum, but what, on examination, proves to be as hard as glass, and consists of opal and chalcedony. Still more wonderful is it when we cut thin sections of the tree and put them under the microscope. We see the minute pattern of the wood cells, which vary in different living trees, and are often most intricate and beautiful in form, faithfully and microscopically replaced by stone; and, by comparing the peculiar pattern with that of sections of the living Sequoia, we find them identical, showing that this stone tree, more than a thousand miles from any living trees of its kind, which are only to be found on the Pacific coast, is, or rather once was, a genuine Sequoia, or big redwood tree.

The question arises, how was this tree so wonderfully changed into stone, and how did it find its way almost alone to the top of the Rockies?

Stone it certainly is; moreover, there is not a particle of the original tree in it, any more than there is flesh and blood in a marble statue or a plaster cast.

It is a not uncommon idea with some people that after death certain living substances or bodies have a mysterious power of turning themselves into stone. Such is not the case. Let an animal die on the prairie, and its flesh rots and passes away. Its skeleton may last a few years longer, but, if it could lie there, preserved, for a thousand years, there is nothing inherent in it that of itself could petrify it, or turn it into stone. So it is when a tree falls to the ground; it rots and becomes soil for other trees to grow on; the tree has no element in itself which is capable of transforming it into stone, still less without diminution of size.

Suppose a tree, like our Sequoia, to grow near a marsh or lake; the waters of the lake in time encroach on its roots and rot or kill the tree, burying the lower portion in mud. The upper part decays and falls into the water, becomes waterlogged, sinks to the bottom, and is entombed in mud, which, by preventing the access of air or water, prevents rapid decay.

In this condition petrifaction may begin. All waters carry a certain amount of minute mineral particles in solution ; some contain iron, others soda or lime ; and, if the waters are acid and heated—as they are apt to be when near volcanic sources—quartz or silica is contained in them, which is deposited as a gelatinous substance, like gum arabic, which afterwards hardens into stone. Our tree then, on the bed of the lake, is saturated with such mineral-bearing waters ; the large open sap veins of the tree are quickly filled with solutions of quartz, forming agate, opal, or chalcedony. Then a wonderful microscopic work follows: As each minute particle and wood cell rots away, it is replaced by a particle of stony matter, until, when the entire living substance of the tree has passed away, a perfect restoration in stone of the tree that lived and perished ages ago is left behind as a monument for all time. Of course, this does not happen to every tree that falls into lake or river; certain waters and circumstances are more favorable than others. Particularly favorable, however, are the waters near a volcanic vent, where hot springs and acid gases abound to dissolve the silica.

The surroundings of this fossil tree are no less interesting than that of the tree itself. The roots are imbedded in shale and sandstone—the solidified mud of a primeval lake. On examining this we find that it is composed of grains and fragments of volcanic lava, sometimes as fine as the finest dust. Opening the leaves of these thin layers of mud with a knife, we found quantities of impressions of insects, such as ants, dragon flies, tropical lanthorn flies, and among them a solitary butterfly, the impression even retaining the pattern of the colors on the wings. Mingled with these were equally perfect impressions of fossil leaves of a semitropical character, such as the fronds of palmettoes. The fossil remains of a sparrow and numerous fossil fresh-water fish have also been found, all indicating a semitropical character for the age. From these remains and other data we gain a history of the lake and its contents.

Some thousands of years before the creation of man, a small lake nestled among these hills, its banks surrounded by a luxuriant semitropical foliage, among which, close to the edge of the lake, towered the great Sequoias.

In the near vicinity, volcanic eruptions took place, and by their violent explosions filled the air with clouds of dust and ashes, which fell, from time to time, in showers into the lake to form its mud; leaves of trees that had been blown into the lake, insects and other living things, water-logged stumps of trees and many forms of vegetation were deeply buried beneath the volcanic mud. Here the hot and acid springs assisted in a fossilizing process. Finally, the eruptions ceased, the lake dried up; floods and glaciers cut ravines in the fossil rock, exposed the petrified stumps, and laid the beds with their fossil treasures open to the chisel of the explorer.

The Sequoias are probably the oldest as well as the biggest trees on this planet—survivals of an age long past—and when we stand gazing at their colossal forms in California we may truly say:

"This was the forest primeval,"

for they were among the earliest genuine trees to appear on this planet at all like those of the present age. Before them there were no forms that we would have recognized as true trees. The earliest forms of plant life—or, if you like, tree life—were seaweeds, growing in a world of waters, a world of an almost universal ocean. Later, upon low islands just above sea level, were forms not unlike the grotesque seaweeds of the ocean, and later still, gigantic weeds and mosses, rushes and ferns—prodigiously magnified swamp vegetation—but still no genuine trees. Not until the middle of the earth's history, when those strange, gigantic lizards came upon the earth, did there appear the first true forest tree, and this was the great Sequoia. But this tree saw the age of lizards and reptiles fade away and give place to that of almost equally gigantic mammals. Later, it saw that marvel of creation, the first man; and its son is with us today, and has seen the railroad train fly through its forest, and the telegraph wire pinned against its bark. In the present age there are but two varieties of the Sequoia known, and they are confined to the little border of the Pacific coast. In ancient times there were twenty-six varieties, which were scattered over the world from the extreme Arctic circle to Australia. This accounts for our finding their fossil remains in Colorado. In all these regions, yes, even under the eternal snows of the Arctic circle in Spitzbergen, Melville Island, and Greenland, similar fossil remains have been found. Nay, more, some of our most eminent botanists and geologists think that the Arctic circle was the paradise of trees, from where they spread south over the globe.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Annexation of the Hawaiian Islands.

THE name Hawaii contains but four different letters, yet the combination seems to be a puzzling one—so many and so various are the ways in which it is pronounced—and the difficulty is increased when the syllable *an* is added, and the word becomes *Hawaiian*. The letter *a* in its various positions is sometimes made long, like *a* in *make;* or short, like *a* in *father;* or broad, like *a* in *fall;* and the *i* may be like *i* in *we*, or like *i* in *pin*. The word appears to have puzzled the earliest European visitors to this remote spot, for, when Captain Cook discovered the islands one hundred and twenty years ago, and tried to reproduce in English letters the name by which the inhabitants called the largest of the group, he spelled it Owhyhee. Captain Cook had been sent into the Pacific Ocean by the British government on a voyage of discovery, and he called the whole group the Sandwich Islands, naming them after the Earl of Sandwich, who was the First Lord of the Admiralty at that period. Some people who have struggled with this inconvenient combination of vowel sounds, and produced a word which they *hope* may be correct, would have been glad if the simple old name had never been changed for the one now universally adopted—the Hawaiian Islands.

The little cluster of volcanic islands rises like a group of steep mountains from the bottom of the Pacific Ocean, and there is a depth of more than three miles of water within a short distance of their shores. On most of the islands the volcanoes have long been extinct, but on Hawaii, the largest of the group, there have been many eruptions during the present century, and one of the mountains, named Kilaulea, has the largest active volcano in the world. Of the twelve islands, four are barren and are uninhabited. They are all very small. The area of the entire group is somewhat less than that of Massachusetts, and the largest island is about the size of the State of Connecticut, while many of the others are as mere specks on the face of the ocean. The names of two of these smaller islands, however, are well known; one is Molokai, the leper settlement, to which all who suffer from the terrible disease of leprosy, and who now number eight hundred, are banished, and are kept entirely isolated from the healthy part of the community. The other is Oahu, on which is situated Honolulu, the capital of the whole group. Honolulu has a fine natural harbor, and here the steamers, which cross and recross the Pacific, stop with mails and with merchandise.

It is this harbor, and others which exist on the coast line of the islands, that makes the group important to the world, by giving facilities for commerce. They are the ultimate cause of the proposition, so warmly advocated in some quarters, that the islands should be annexed by the United States of America. Their position with regard to the highways of commerce on the Pacific Ocean is a very central one. A line drawn on the map from San Francisco, or from Victoria in British Columbia, to New Zealand, or to Australia, or to China, will in each case pass within a few hundred miles of these islands. It is probable that the isthmus between the two Americas will, ere many years have passed, be intersected by a canal, and then the ships from the Atlantic coast ports and from Europe, passing through this canal to China and Japan, will also be within easy reach of the islands.

The commercial value of any spot of land, however, does not consist only in its accessibility. What has it to sell, and what does it want to buy, are questions of the first importance. The chief article of export of the Hawaiian Islands is sugar, and of this the United States buys almost the whole

quantity produced. Rice is cultivated to a moderate extent, and coffee, fruits, and wool are exported in increasing quantities year by year. The total value of exports from the islands in 1896 was fifteen and a half million dollars, while the imports amounted to but seven million. The importance of the islands is therefore not very great at present. Perhaps it is scarcely to be expected that their purchasing power should be great when the size and character of the population is considered. The inhabitants of the entire group number only 116,000; we have in the United States from thirty to forty cities each of which has a larger population. Rather more than one-third—40,000—are Hawaiians, either of pure or of half blood; nearly one-half—52,000—are Chinese and Japanese, about equally divided; and all other foreigners, among whom Portuguese predominate, number about 24,000, of whom only 3,000 are Americans. The demand for the manufactured products of the United States is therefore not likely to be large. The climate is warm, so the needs of the inhabitants in the matter of clothing are few, while the natural products of the soil suffice for food. At present the capacity for production is greater than the capacity for consumption.

There is, however, another aspect to the question. Lying thus, midway in the Pacific Ocean, these islands have a value to other nations as well as to Americans, if not for commercial, yet perhaps for strategic purposes in case of war. Pearl Harbor, on the Island of Oahu, is said to be one of the finest natural harbors in the world, and easily convertible into a naval station. No less than four nations are supposed to cast covetous glances at the Hawaiian Islands. Great Britain might establish a convenient halfway house between Vancouver and New Zealand. Japan, overcrowded in her island empire, is thought to have designs on Hawaii, where already more than one-fifth of the population are subjects of the Mikado. Russia might stretch out a long arm from her newly acquired Chinese ports, and seize Hawaii as a link between the two continents. Germany, just now in the first flush of enthusiasm for colonial expansion, would find Hawaii, and especially Pearl Harbor, a valuable acquisition.

None of these suggestions, which are only samples of the product of fertile imaginations, has ever been seriously made. They are like the cry of "Wolf!" raised in order to hurry the United States government into the acceptance of a responsibility for which she is not yet prepared. It is true that an unsuccessful attempt was made by Great Britain a few years ago to secure the cession of a rocky islet remote from the Hawaiian group, but recognized as within its jurisdiction, for use as a cable station for a proposed cable between Vancouver and New Zealand; and it seems probable that the day will come when, with the consent of many interested nations, these islands may be a neutral spot at which the paths of several Pacific cables will intersect one another, for commerce feels the need of rapid communication between all its important centers. But up to the present time the only serious proposition for the annexation of the group has come from the United States, which have been invited by a section of the inhabitants of Hawaii to take this step. That trade would be temporarily stimulated by such action on the part of this country is probable; but the future effect on the prosperity and population of the islands is doubtful, in view of the large numbers of Chinese and Japanese laborers now employed, who are not acceptable as citizens of the United States.

The islands are often spoken of as a valuable defensive outwork, and so important an authority as Captain Mahan takes this view of them. Others again consider that they would be of much more use to an attacking than to a defending power. If any nation wished to attack our Pacific coast it is said that these islands (although they are rather distant for the purpose) would be seized and used as a base of supplies. Great Britain is the country to which jingoes usually attribute such unfriendly intentions, and she already has a better and nearer base of supplies at Vancouver. If the Hawaiian group belonged to the United States, it would form an exposed and vulnerable point of attack, and would need strong fortifications and many ships and troops for its defense. On those few hundred miles of coast line are no less than thirteen harbors, whereas along our Pacific coast there are but two, and in defending these two harbors our base of supplies would not be two thousand miles distant, as would be the case with Honolulu and Pearl Harbor.

Emphasis is often laid on the axiom that "Trade follows the flag"; but the size of the territory concerned has much to do with its value as regards trade, and the capacity for expansion of trade in those small islands is necessarily limited. The bulk of their commerce is already in American hands,

and the predominance of the interests of the United States in all questions connected with them is recognized by other nations.

The Hawaiian Islands have been Christianized, and since 1894 the government has been republican in form. If, however, annexation takes place, the tendency will inevitably be towards an oligarchy, that is, the rule of a small governing class; for, as has been said, the population includes only 3,000 Americans, and their superior education and civilization, and the dominating characteristics of the race to which they belong, will cause the power to rest mainly in the hands of this small minority who already exercise a strong influence over the political concerns of the islands. Only those men who are of Hawaiian, American, or European birth or descent can become full citizens and voters. The large Chinese and Japanese element, forming together nearly one-half of the population, is thus without representation in the government, and annexation would probably lead to the gradual exclusion of them from the country, and deprive the planters of their supply of cheap labor, which at present renders the sugar industry a very profitable one.

The islands offer many attractions to visitors. The scenery is beautiful; the climate, although within the tropics, is agreeable; the temperature rarely rises above 90°, or falls below 55° Fahrenheit; and except in the month of December the rain fall is not excessive. Already there are about a hundred miles of railroad, steamers make frequent trips among the islands, and there is regular communication with American and Canadian ports. There is so much to interest the tourist that it would appear as if the acquisition of so agreeable a summer resort was to be made a strong argument for the annexation by this country of this charming group of islands, the so-called key of the Pacific.

Yet, whatever may be the value, either commercially or strategically, of this offered possession, the Great Republic does well to think twice before she adds Hawaii to her family of states, and gives a vote in her councils to its representatives. The native islanders are but two generations removed from barbarism, and from a gross and revolting form of heathenism; while within the memory of living man they have been known to practice cannibalism. Leprosy, almost unknown among people of our own race, is prevalent there. Although Christianity and civilization are readily accepted, yet we know that neither moral nor physical hereditary tendencies can be eradicated suddenly. It is not proposed that these islanders should be ruled as a subject race but that they should be received into the Union on equal terms, and given their full share in the management of national affairs. The past history of this country proves that such an experiment would be at best both doubtful and hazardous.

THE SPANISH-AMERICAN WAR.

AFTER the lapse of thirty-three peaceful years, we, the people of the United States, see our country again at war, and this time with a foreign, and, heretofore, a friendly power. The circumstances that have led to this war are well known, and may be briefly stated. Cuba, the largest of the West Indian islands, lying 130 miles south of Florida, has been a colony of Spain since the year 1511. During the past century, the government of Cuba has been of a harsh and oppressive character, and the inhabitants have made many attempts to secure their independence. For three years a large number of the Cubans have been in a state of armed rebellion, and Spain, in her efforts to reduce the island to order, has resorted to measures which her neighbors regard as severe and cruel. It is for the purpose of repressing these disorders, and of freeing the Cubans from their dependence on a foreign power, that our country has taken up arms against Spain.

The situation has been complicated by the popular indignation aroused by the destruction, on February 15th, 1898, of the battle ship Maine, and nearly all her crew, while lying at anchor in the harbor of Havana. This incident, however, is not regarded as a just cause of war, since no absolute proof that it was the result of a deliberate act on the part of Spain has been adduced.

During the progress of the war a portion of the space allotted, in the HOME STUDY MAGAZINE, to "Current Topics" will be devoted to a brief record of the important events that take place, month by month.

April 19th, 1898. Both Houses of Congress concurred in the resolution that armed

intervention in the affairs of Cuba should take place.

April 20th. The Spanish minister, Senor Don Luis Polo y Bernabé, left Washington.

April 21st. Spain refused to receive the ultimatum sent by the United States, and desired the American minister, General Woodford, to leave Madrid.

April 22d. American ships of war moved southward. The blockade of Havana began.

April 23d. The Spanish battery at Matanzas fired on the American gunboat Foote.

April 24th. Declaration of Spain that diplomatic relations had been broken off, and that a state of war had begun.

April 25th. Congress declared that war existed since April 21st, when diplomatic relations were broken off between Spain and the United States. President McKinley called for 125,000 volunteers. Asiatic squadron sailed from China to blockade the Philippine Islands.

April 27th. Forts at Matanzas shelled by the New York, the Puritan, and the Cincinnati. Guns of the forts silenced in about 18 minutes. None of the American vessels were struck.

Neutrality has been guaranteed by the governments of Great Britain, France, Russia, Italy, Norway and Sweden, Switzerland, the Netherlands, Belgium, Portugal, Brazil, Colombia, the Argentine Republic, Mexico, China, and Korea.

Spanish vessels captured since war broke out: April 22d, Buena Ventura, by gunboat Nashville; April 23d, Pedro, by cruiser New York, and Mathilde, by gunboat Porter; April 24th, Catalina, by cruiser Detroit; Saturnina, by revenue cutter Winona; Canelita, by gunboat Wilmington; Miguel Jover, by gunboat Helena; Sofia, by gunboat Porter; April 25th, Panama, by lighthouse tender Mangrove; April 27th, Bolivar (with $60,000 in silver on board) and Saco, both by monitor Terror; April 28th, Guido, by monitor Terror and gunboat Machias. (Some of these vessels may be returned to their owners, as having been seized before the war regulations, with regard to shipping, went into effect.)

Our record closes on April 28th.

DAINTY DESSERTS.

Mrs. Henry Esmond.

ORANGE JELLY WITH COCOANUT—PINEAPPLE PUDDING—PRUNE PUDDING—RHUBARB—IRISH MOSS BLANC MANGE—TAPIOCA CREAM—FRUIT SNOW.

Orange Jelly With Cocoanut.—This dessert is similar to ambrosia—the receipt for which was given last month—but is more delicate. Soak ½ box of gelatine in ½ cup of cold water until it has taken up all of the water. While the gelatine is soaking, squeeze the juice from 4 good-sized oranges; to this add ½ cup of granulated sugar. When the gelatine is thoroughly soaked, add to it 1 cup of boiling water, and stir it into the orange juice and sugar. Strain through a wire sieve into a bowl and set in a cool place to stiffen. In warm weather, jelly made with gelatine takes longer to stiffen than in winter, and it is then necessary to stand the bowl in a pan of chopped ice. Just before serving, whip ½ pint of cream quite stiff, sweeten with 1 tablespoonful of granulated sugar, and add ½ of a fresh cocoanut, grated. If you cannot get a fresh cocoanut, the shredded, prepared cocoanut may be used. In this case use 1 cup of cocoanut and soak it until soft in ½ cup of cream. Wrap a cloth wrung out of hot water around the bowl that contains the jelly, and turn it out into a shallow dish. The hot cloth melts the jelly just enough for it to slip out without spoiling its shape. Pile the whipped cream and cocoanut over the jelly, and it is ready to serve. This is a very delicate and delicious dessert.

Pineapple Pudding.—Pare 1 pineapple, remove all the eyes, and grate as quickly as possible, being careful not to grate any of the tough center. Sprinkle ½ cup of sugar over it, and set aside for the sugar to melt. Soak ⅓ box of gelatine in ⅓ cup of cold water; when the water is all soaked up add ½ cup of boiling water, and stir until the gelatine is all dissolved. Put the pineapple into a good-sized bowl, and set the bowl into a pan of chopped ice. Mix the gelatine into this, and, when partially stiff, fold in 1 pint of whipped cream. Do not whip the cream

too stiff. Pour into a deep bowl, which is a good shape, or a jelly mold, and let it get stiff and cold. Turn out into a shallow glass dish and serve.

Prune Pudding.—Before explaining the making of this very delicious pudding, we wish to say a few words about prunes. We often hear people say, when asked if they like prunes, "Prunes! I can't bear them; they're a regular boarding-house dish." Well, this may be so, but, if prepared properly, they are extremely palatable, and they are also very wholesome. There is more in the preparing than in the cooking of prunes. First, they should be thoroughly washed in warm water. Rub them well between the hands until perfectly clean. Put them in a stone crock or an earthenware bowl, cover with cold water, and let them soak over night. In the morning set the crock, or whatever the prunes are in, on the back of the stove where they will stew slowly, not boil vigorously, as this is apt to break them. Let them cook two hours; then add ½ cup of granulated sugar per pound of prunes. When done they will be plump and soft, not wrinkled, hard, and dirty, as served in many boarding houses. They are much nicer if the pits are removed; this is easily done after cooking by pinching each prune between the thumb and finger.

For prune pudding use 1 pound of prunes. Do not add any sugar, as less is required than for stewed prunes. Pour off the water in which they have been cooked; let them cool and remove the pits. When cool, rub them through a coarse wire sieve. Beat the whites of 4 eggs *very* stiff and fold them quickly into the prune pulp, and add 3 tablespoonfuls of granulated sugar. Pour into an ungreased baking dish, and bake in a moderate oven for 20 minutes. Remove from the oven and let cool in the kitchen before setting in a very cold place to get thoroughly cold. If any beaten-egg mixture which has been baked is stood immediately in a cold place, it will fall; this is due to the fact that the steam and hot air contained in the minute cavities extending throughout the mixture is suddenly cooled, leaving a partial vacuum in each cavity, which causes the whole mixture to collapse under the pressure of the atmosphere.

Rhubarb.—Cut 1 dozen stalks of rhubarb into pieces 1 inch long. Put in a large bowl and cover with boiling water. Let it stand for 10 or 15 minutes, then pour off the water. This water draws out an acid in the skin which is not good; it also seems to soften the skin and makes peeling unnecessary. This saves time and also rhubarb, a good deal of rhubarb being wasted in peeling. Put it on to cook with 1 cup of water, and let it cook slowly until it is all in shreds. Remove from the fire and add ½ cup of granulated sugar.

Never cook fruit or acid vegetables in copper or tin vessels, as the acids act on these metals and discolor them. Tin is turned black and the chemical compound formed is poisonous; this black substance is the same as that which appears on tomato cans that have been opened and left exposed to the air. Use either granite or porcelain; or, where it is not to come in contact with the fire, earthenware is very good.

Rhubarb is one of the most wholesome fruits. It is not only very nice and refreshing but it is a good spring tonic.

Irish Moss Blanc Mange.—Wash 1 ounce of Irish moss in warm water; pick out all the dark pieces. Let it soak 5 minutes after it is perfectly clean. Put 3 cups (1½ pints) of water into a double boiler and add the moss. Let it cook, stirring quite often, until the moss is almost all dissolved; all the feathery part will dissolve and leave only the stem. Strain through cheese cloth or an old napkin into cups, and set away to stiffen and cool. Serve with sugar and cream or with fruit, either preserved or fresh. This is especially nice for invalids or sick persons. If you have no double boiler use a bowl set in a pan of hot water.

Fruit Snow.—Either apples, peaches, apricots, strawberries, or blackberries may be used for this very dainty and quickly made dessert. The apples should first be steamed, but any of the other fruits may be used raw. Core and pare the apples and steam them until tender. Let them cool, and then rub them through a coarse wire sieve. Beat the whites of 4 eggs just as stiff as it is possible to beat them, and add ½ cup of granulated sugar and the fruit pulp. Beat again with the egg beater until the egg and fruit are thoroughly mixed. Pour into a jelly mold or a deep bowl, and set it in a pan of chopped ice (or on the ice in the refrigerator) to chill. Serve with whipped cream. Follow these directions for any of the fruits. This is particularly delicious when made with either peaches, apricots, or strawberries.

(193) Answer to Inquiry No. 100, in the March, 1899, issue of HOME STUDY MAGAZINE puzzles me. Are you sure it is correct? C. L., Baltimore, Md.

ANS.—Yes, the answer is correct, but to make it intelligible to any one but a student of higher mathematics is practically impossible, and, if it were possible, we could not afford space for it. These columns are for the benefit of the average reader of the magazine, and, in answer to questions similar to the one you refer to, the most we feel justified in doing is to give the answer, together with such figures as are necessary to us in arriving at that answer. We take this stand because we feel sure that 99 per cent. of our readers care nothing for the solutions of abstruse and purely mathematical problems that are as difficult to follow as the one under consideration.

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(194) Will you kindly explain the working of Mr. S. H. Taylor's (of Montreal, Canada) hydraulic air compressor? By the Taylor system, power is delivered in the form of compressed air, which is generated to any desired pressure directly from the falling water. The first commercial plant installed under this system was one of 150 H. P. placed in the cotton mills at Magog, Quebec, in 1896. This has attracted much attention and has won the favor of engineers on both sides of the Atlantic.
H. G., Qu'Appelle Station, Canada.

ANS.—You will find an article entitled "A Simple Air Compressor," on page 216, of this magazine, which is an answer in full to this question.

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(195) (a) In treating a small piece of pyritic ore for gold, and by crushing and adding one drop of mercury and a small piece of cyanide of potassium, then placing in a test tube or matrass after cleaning the mercury, how can I volatilize it? (b) What is the size of a drop? (c) Can I volatilize the mercury by placing it between two small cupels and applying the blowpipe, or would there be danger from the fumes evolved? F. 195, Cape Town, South Africa.

ANS.—(a) Unless you had a very rich ore, you would hardly be able to get any results at all from a *small piece* of the ore. The usual method of amalgamation assay is to pulverize 3 or 4 pounds of ore and then wash off all the gangue in an ordinary gold-pan. The gold and pyrites or other heavy mineral left in the pan are transferred to a flask, a few ounces of mercury added, according to the richness of the ore, and enough boiling water to make a thin pulp. Shake the flask for a few minutes, to insure contact of all the gold with the quicksilver, and then wash several times to get rid of most of the sand. Finally pour contents of flask into the pan and clean the mercury thoroughly by washing, and then strain. The mercury may be driven from the lump of strained amalgam by heating in a porcelain or iron crucible, either in a muffle or under a hood. (b) Speaking generally, the size of a drop depends upon the viscosity of the liquid and the shape of the surface from which the drop releases itself. In this case, the word drop means a small quantity of mercury. (c) We would not advise such an experiment as you suggest. If you have neither muffle nor hood handy, a somewhat primitive device may be resorted to. The amalgam is laid on the blade of a shovel, or any piece of sheet iron, and is covered with half of a raw potato, in the middle of the cut face of which a hole has been dug. The shovel is then heated gradually to a low red heat and kept there for several minutes. The first heat bakes the potato into the shovel and prevents the escape of fumes. When the shovel is cooled and the potato removed, the gold will be found as a spongy mass, and the mercury will be clinging in globules to the sides of the cavity in the potato.

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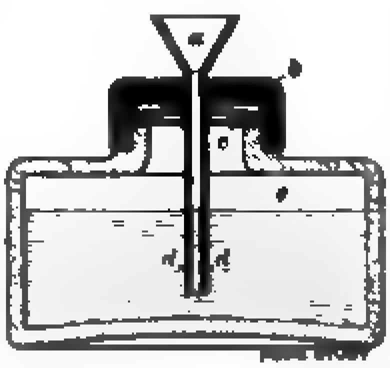
(196) (a) Please tell me how to fill and use the Davis automatic inkstand. (b) Of what are the pneumatic mattresses made that are used on shipboard? M. A. G., Port Henry, N. Y.

ANS.—(a) To fill the inkstand, simply remove the cap *b* and pour in the ink. The action of the inkstand is as follows: The pen is dipped in the conical funnel *a* in the ordinary manner; the pressure downward causes the rubber diaphragm *c* to partially close up the air space *e*, thus slightly compressing the enclosed air. This small excess of pressure forces the ink through the holes *d* up the tube into the funnel *a*, thus filling the pen. (b) We do not know, having never heard of them before.



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(197) (a) What, in simple language, is the moment of inertia? (b) How is it calculated, say on a steel-plate girder 25 feet long between supports, and 2 feet 6 inches deep, with distributed load of 1,500 pounds per foot, and a concentrated center load of 15,000? Required, the necessary moment of inertia for a strain of 12,000 pounds on extreme fibers.
J. C. E., Providence, R. I.

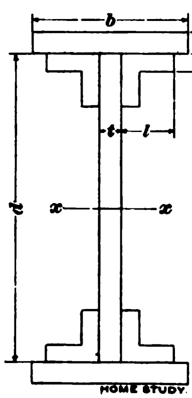
ANS.—(a) The moment of inertia of a body or plane section relates to its rotative effect with reference to a given axis. The moment of inertia of a plane surface about a given axis is the sum of the products of the elementary areas into which the surface may be conceived to be divided, by the squares of their distances from the axis. The moment of inertia of the vertical section of a beam, or girder, is a value convenient to use in determining its strength. It is a quantity entering into the expression for the moment of resistance of beams. (b) In order to determine the moment of inertia required for a beam, it is necessary to first determine the maximum bending moment produced by its load. For a uniformly distributed load upon a single beam, the maximum, or

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see advertising page II.

center-bending, moment M is given by the formula $\frac{W\,l}{8}$, in which W is the total load, and l is the length of span; for a load concentrated at the center, it is $\frac{W\,l}{4}$. In order that the result may be in inch-pounds, l should be expressed in inches. The total maximum bending moment for the beam given in the example is therefore equal to

$$\frac{1{,}500 \times 25 \times 25 \times 12}{8} + \frac{15{,}000 \times 25 \times 12}{4} = 2{,}531{,}250 \text{ in. lb.}$$

The bending moment due to the weight of the beam itself should be also included. The resisting moment of the beam must be equal to the bending moment upon it. For any beam, the moment of resistance R, is given by the formula $R = \frac{S\,I}{c}$, in which I is the moment of inertia, S is the stress in the extreme fiber, and c is the distance of the extreme fiber from the neutral axis or center of gravity of the section. In case of a symmetrical section, the neutral axis is, of course, at the center of its depth, and c will be equal to one-half the depth of the beam; in the present case $c = \frac{30}{2} = 15$ inches. By writing the resisting moment equal to the bending moment, as obtained, we have the equation $\frac{12{,}000\,I}{15} = 2{,}531.250$, from which the required value of I is found to be 3,164. In order to find the dimensions of a girder that will have this moment of inertia, it will be necessary to assume a section and compute its moment of inertia. For any section that can be divided into rectangles, the moment of inertia can be found by applying the following values for a rectangular section: I. *The moment of inertia of a rectangular section, with neutral axis through center of gravity, is* $\frac{b\,d^3}{12}$, *b being the breadth of the section, parallel to neutral axis, and d the depth perpendicular to neutral axis.* II. *If the neutral axis does not pass through the center of gravity, the moment of inertia is equal to* $\frac{b\,d^3}{12} + b\,d\,y^2$, *y being the distance from the center of gravity to the neutral axis.* Most plate girders are of the general form shown in accompanying figure, though the cover, or flange, plates are often omitted.



By applying the above values for rectangular sections, we obtain the following expression for the moment of inertia of this section, the angles having equal legs:

$$I = \tfrac{1}{2}\,b\,c\left[\frac{c^2}{3} + (d+c)^2\right] + a\,(l-a)\left[\frac{a^2}{3} + (d-a)^2\right] + a\,l\left[\frac{l^2}{3} + (d-l)^2\right] + \frac{t\,d^3}{12}.$$

If we try a section made up by a $30'' \times \frac{3}{8}''$ web-plate, and four $4'' \times 4'' \times \frac{3}{8}''$ angles, we will have $d = 30''$, $l = 4''$, and $a - t = \frac{3}{8}''$. As there are no cover-plates, the expression $\frac{1}{2}\,b\,c\left[\frac{c^2}{3} + (d+c)^2\right]$ will disappear from the formula and we will have for this case,

$$I = \frac{3}{8} \times 3\frac{5}{8} \times \left(\frac{3}{64} + 29.625^2\right) + \frac{3}{8} \times 4 \times \left(\frac{16}{3} + 26^2\right) + \frac{\frac{3}{8} \times 30^3}{12} = 3{,}058.86,$$

which is somewhat less than the required moment of inertia, as found above. By increasing the thickness of the angles to $\frac{7}{16}$ of an inch, a sufficient moment of inertia will be given. The moment of inertia is used in determining the strength of solid-rolled beams, but is not commonly employed for determining the strength of plate girders.

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(198) I wish to erect a cable bridge across a stream as in Fig. 1—a single cable with a car running on it. The distance $A\,B$, the amount of sag h, and the combined weight of the car and contents are known: (*a*) What is the formula for finding the pull on each end of the cable, and (*b*) how can I calculate the pull caused by the weight of the cable itself, in order to decide upon the size of cable? (*c*) What factor of safety should be used in a bridge of this kind? (*d*) A and B, in Fig. 2, are anchor bolts; how do they compare for anchoring in rock, Portland cement, sulphur, and lead? W. T. C., New Castle, Cal.

ANS.—(*a*) Denoting the span $A\,B$ by l, the sag by h, the combined weight of the car and its contents

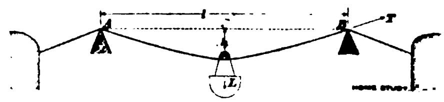

FIG. 1.

by L, and the weight of the cable per unit of length by w, the following formula will give the approximate tension T at each end of the rope.

$$T = L\left(\frac{l}{4\,h} + \frac{4\,h\,L}{l^2\,w + 2\,l\,L}\right) + \frac{l^2\,w}{8\,h} + h\,w.$$

(*b*) To determine the proper size of rope, you must accordingly assume a certain size, and figure the tension produced on it, and then see whether this is too great or too low for it. If the tension proves too great for the rope thus assumed, you assume a smaller one and try again, and so on until you get satisfactory results. (*c*) The proper factor of safety will depend on the frequency with which the car is to be loaded to its full capacity. It may lie anywhere between, say, 3 and 6. (*d*) Of the two forms of anchor bolts shown, the form B is the more satisfactory for the purpose of setting in a hole drilled in the solid rock. We have some doubts, however, as to whether an anchorage of this kind can be made safe for resisting

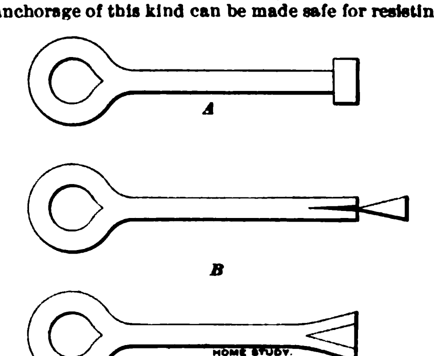

FIG. 2.

the direct pull of a cable such as is shown in Fig. 1, though it is possible that it can be if the hole is drilled to a considerable depth, its bottom well enlarged and the anchor bolt driven well down over the wedge so as to have a firm grip on the rock before the filling material is poured in. We would prefer

neat Portland cement for a filling material; it must be allowed sufficient time to set. We have heard it stated that a cement composed of about equal parts of sulphur and broken glass, melted together, forms an excellent anchorage filling, but have no positive knowledge concerning it. One of the best forms of anchor bolts for such purposes is a rod of considerable length, having a nut or key at the end, and carrying a large cast-iron washer that can be anchored under a sufficient weight of masoury to resist the pull of the cable.

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(199) Please tell me what is meant by "beads" in the following example, also show solution and rule for same: A boiler is 66 inches in diameter, 16 feet in length, thickness of shell $\frac{3}{8}$ inch. The beads are $\frac{7}{16}$ inch in thickness. What is the safe working pressure? W. H., Buffalo, N. Y.

ANS.—The word "beads" is evidently an error; it should have been "heads." For the computation of the safe working pressure in cylindrical boiler shells, the following rule is used: Multiply the thickness of plate in inches by one-sixth of the tensile strength of the metal and divide the product by half the diameter of the shell in inches. Thus, in your example, taking the tensile strength of plate equal to 60,000 pounds:

$$\frac{3}{8} \times \frac{60{,}000 \times \frac{1}{6}}{33} = \frac{10{,}000}{88} = 113.63 \text{ lb. per square inch.}$$

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(200) In the origin of the English system of weights and measures, the length of a pendulum was divided into 39.1393 equal parts. Why was it divided into that number of parts, and how was it done? F. H. B., Providence, R. I.

ANS.—A *simple* pendulum consists of an exceedingly small, heavy body suspended from a fixed point by a string whose weight may be neglected, and capable of vibrating in a small arc. Any other pendulum is called a *compound* pendulum; thus, all clock pendulums are compound. If T denotes the number of seconds a simple pendulum takes to vibrate from the highest point on one side to the highest point on the other side, l denotes the length of the pendulum in feet, and g denotes the increase of velocity in feet per second, which a body falling freely under the action of gravity gains in one second; it can be shown that

$$T = \pi \sqrt{\frac{l}{g}}.$$

When the length of the second's pendulum is known this formula enables us to calculate g, the acceleration due to gravity. At sea level, in London, l is found to be 3.2615 feet, or 39.13983 inches, which gives g equal to 32.1912. It is by pendulum experiments that the value of g, for any place, is actually found. Now, suppose the British standard yard were destroyed or lost, it could be restored by constructing a simple pendulum to beat seconds, and dividing the length of that pendulum into 39.1383 equal parts, then 36 of these equal parts would make a yard. The best method of determining the length of the simple pendulum, which vibrates in a given time, is due to Captain Kater, and was published by him in the *Philosophical Transactions*, 1818 and 1819. A description of his method is too long for insertion in this column. In 1818 a Royal Commission, with Sir George Banks, president of the Royal Society, as chairman, was appointed to examine the weights and measures used in England. The recommendations of this commission were embodied in a statute which became law on January 1st, 1826. This statute provided that the standard yard shall be the length, at 62° Fahrenheit, of the straight line between the centers of the two points in the gold plugs in the brass rod in the custody of the Clerk of the House of Commons, on which are engrossed the words, "Standard Yard, 1760." In case the standard is lost, or destroyed, the statute provides that it shall be restored by reference to the length of the pendulum which beats seconds of mean solar time in London at sea level, in a vacuum; the length of this pendulum is declared by the statute to be 39.1393 inches. In 1834, the Houses of Parliament were destroyed by fire, and a Royal Commission, under Sir George Beddell Airy, astronomer royal, was appointed to investigate the best method of restoring the standards. This commission reported against the pendulum method of fixing the standard of length, on the ground that the original determination of the length of the seconds pendulum was inaccurate, and favored adopting, as standard, the length of a then existing yard which had been recognized by the Standard's Commission of 1818. In England this standard yard was legalized in 1855. It is also the standard yard of the United States.

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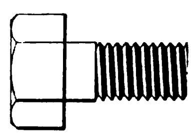
(201) (*a*) Please show me rule for figuring out the compression space of a 6-inch (diameter of cylinders) by 7-inch (stroke) gas or gasoline engine, at 300 revolutions per minute; two cylinders. (*b*) What is the difference between machinery steel and cold-rolled steel; also, what are the standard sizes, or sizes usually kept in stock? (*c*) Is the enclosed a sketch of a capscrew or of a tap bolt? (*d*) Give some information on drop forgings, how they are made, etc. (*e*) Explain the term displacement as applied to a boat or ship. (*f*) Name one or two good books on marine engineering, and on marine and stationary gas and gasoline engines. X. Y. Z., Philadelphia, Pa.

ANS.—(*a*) When using tube or electric ignition, the average practice is to make the volume of the compression space one-third of the volume displaced by the piston. The volume displaced by the piston of a 6″ x 7″ engine is $\left(\frac{6}{2}\right)^2 \times 3.1416 \times 7 = 198$ cubic inches nearly; and $198 \div 3 = 66$ cubic inches, the volume of the compression space. If this space is a continuation of that part of the cylinder traversed by the piston, the above calculation can be simplified, since the length of the space will be $7 \div 3 = 2\frac{1}{3}$ inches, or $2\frac{3}{8}$ inches approximately. (*b*) Machinery steel is the name generally applied to that grade of Bessemer or open-hearth steel commonly used for such purposes as shafting, piston rods, and similar machine parts. Cold-rolled steel is steel finished for such purposes as shafting or piston rods by passing it through grooved rolls while cold; it is thus polished and finished so as to be ready for use without any further treatment. The Jones & Laughlins Company, of Pittsburg, Pa., advertise about 60 different sizes of round cold-rolled steel between $\frac{1}{4}$ inch and $4\frac{1}{2}$ inches in diameter as being kept in stock at the mill; they also keep several sizes of cold-rolled steel squares and flats in stock ready for immediate delivery.



(*c*) Both capscrew and tap bolt are used by different people to designate the form of bolt shown in your sketch. When the bolt is finished all over, it is usually called a *capscrew*. When left rough, the term "*tap bolt*" is commonly applied to it. However, usage of these terms varies somewhat in different localities, the two terms being occasionally applied indiscriminately to the same thing. In some localities the distinction between the two terms is to confine the term capscrew to small bolts or screws, especially those having slotted heads instead of hexagonal or square heads. (*d*) Drop forgings will be made the subject of an early article in HOME STUDY MAGAZINE. (*e*) The term "displacement," when applied to a vessel, refers to the weight of the water displaced by the

immersed portion of the hull. It is always expressed in tons (2,000 pounds). (*f*) An excellent book on Marine Engine Design is "Manual of Marine Engineering," by Seaton. If you wish a book on the running of marine engines, we would recommend "Reed's Engineers' Hand Book." A good book on gas engines is "The Gas and Oil Engine," by Dugald Clerk. "Gas, Gasoline, and Oil Engines," by Gardner Hiscox, contains a number of illustrations of modern gas and gasoline engines. These books can be obtained from the Technical Supply Co., Scranton, Pa.

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(202) Give me a few practical suggestions for constructing a refrigerator or ice box for home use, in which the water from the melting ice is *not* to be used for drinking purposes. The ice box is intended solely for the preservation of milk, butter, meats, etc.
G H W., Hokendauqua, Pa.

ANS.—The accompanying sketch is a vertical section through such an ice box as you appear to want. It is simply a common box like an ordinary refrigerator, like those kept in stock and for sale in hardware stores. The principal points to be considered in building a home-made refrigerator are: First, build the walls hollow, and fill in between them with mineral wool, charcoal, ground cork, sawdust, or any loose material which is a slow conductor of heat, the main object in ice-box construction being to prevent, as much as possible, the heat of the air outside of the box from being transmitted to the inside air. Second, build the ice receptacle in the upper part of the box. Place a perforated or slatted screen *a* in this receptacle, to support the ice, and provide the lowest point with a drop flue *b*, keeping its lower end about 3 or 4 inches up from the bottom, so that the cold air in the ice receptacle may fall by gravity into the lower chamber of the chest, i. e., the cold-storage chamber. Provide an opening at *c* between the top of the cold-storage chamber and the ice receptacle, so that a good circulation of air can be maintained throughout the apparatus in the direction indicated by the arrows. By this simple arrangement you can keep the food at a low temperature. Of course, you must make the chest as nearly air-tight as possible, otherwise you will lose cold air and waste the ice. Line the chest with 14- or 16-ounce sheet zinc and provide a 1-inch or 1¼-inch drip pipe and strainer at *d* to lead away the melted ice. Make and fit up some kind of a water-sealed trap at *e* to prevent the cold air from escaping through the waste pipe. Let the waste pipe *f* from this trap discharge openly over and into a water-supplied sink or the open air, and your job will be complete and perfectly sanitary.

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(203) (*a*) Will the ball of a cannon which is fired from the rear end of a train going at the rate of a mile a minute go as far from the place of firing as a ball fired from a cannon on the ground? Please give explanation of the foregoing (*b*) Why do whirlwinds and whirlpools always turn to the right?
J. L. T., Mayton, W. Va.

ANS.—(*a*) No. If the velocity of the ball with respect to the cannon is exactly equal to the speed of the train, it is evident that the actual velocity of the ball with respect to the earth is zero and that the ball will fall directly to the earth from the point where it leaves the cannon. In any case the actual velocity of the ball with respect to the earth will be equal to the difference between the relative velocity with which it leaves the cannon and the speed of the cannon with respect to the earth. (*b*) Whirlwinds and whirlpools do not always turn to the right. In fact, the whirlwind usually turns to the left when it is north of the equator. (See HOME STUDY MAGAZINE, November, 1897, article entitled "Cyclones.")

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(204) (*a*) Can you give me the name and address of the manufacturers of the gas producer described in HOME STUDY MAGAZINE, January, 1898, article entitled "The Gas Engine"? (*b*) I also wish you would give me the name and price of a book giving detail directions for the construction and operation of a plant for making iron by open-hearth charcoal process.
G. D. H., Dallas, Texas.

ANS. (*a*) The manufacturers of the gas producer are the Otto Gas Engine Works, 33d and Walnut Sts., Philadelphia. (*b*) There is no book printed giving a detailed description of the construction of a plant for making iron by what is generally known among metallurgists as the *open-hearth process* in which charcoal is employed. There is, however, a method of making iron with charcoal as fuel in what is known as a *bloomary* furnace. The most complete description of this process we know of is that given in the Transactions of The American Institute of Mining Engineers, Vol. VIII, in a paper entitled "The American Bloomary Process," by Thos. Eggleston. A copy of the volume may be obtained from the Secretary of the American Institute of Mining Engineers, Mr. R. W. Raymond, 13 Burling Slip, New York.

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(205) Is it necessary to fit a 1-inch punch for punching ½-inch or $\frac{9}{16}$-inch boiler iron or steel, just as close as for tin or sheet iron and brass?
F. W. V., Rochester, N. Y.

ANS.—For very thin sheets the punch may certainly be made a better fit in the die than when used for boiler plates. The thin sheet metal will bend around the edge of the hole, under the pressure of the punch, much more readily of the two, and will therefore require supporting, that is, the die must approximate more closely to the size of the punch. Also, there will always be a certain amount of play in the slides, and therefore any slight inequality of plate thickness, or other contingency that might cause

the punch to deviate from a vertical direction, would have more effect in the case of a thick plate; that is, by the time the punch had moved through a distance of $\frac{3}{4}$ inch from entering the metal, it will have deviated much more than if the metal were only $\frac{1}{16}$ inch thick. No hard and fast rule has been given in connection with this matter, so far as we know. In exact work, where the sides of the hole are required to be parallel throughout, the punch must be a better fit than in, say, bridgework, where it is less of a disadvantage to have the holes slightly conical, provided, of course, the plates be placed with the small ends of the holes together. Different people possess, doubtless, different opinions on the matter; but, if you follow the annexed table which we have drawn up, you ought not to go far wrong. In practice, however, the same sets of dies and punches are generally used for all plates, where the range of thickness is not very great. In such a case, make the dies from $1\frac{1}{10}$ to $1\frac{1}{16}$ times the punch diameter, reckoning from the smaller sizes upwards.

Diameter of Punch d.	$\frac{3}{16}''$ to $\frac{1}{2}''$	$\frac{9}{16}''$ to $1''$	$1\frac{1}{16}''$ to $1\frac{3}{16}''$
Thickness of Plate.	Diameter of Die.	Diameter of Die.	Diameter of Die.
$\frac{1}{16}''$ to $\frac{1}{4}''$	$1\frac{1}{12}d$	$1\frac{1}{32}d$	$1\frac{1}{32}d$
$\frac{5}{16}''$ to $\frac{5}{8}''$	$1\frac{1}{8}d$	$1\frac{1}{16}d$	$1\frac{1}{20}d$
$\frac{11}{16}''$ to $1''$	....	$1\frac{1}{12}d$	$1\frac{1}{16}d$
$1\frac{1}{16}''$ to $1\frac{1}{4}''$	....	....	$1\frac{1}{11}d$

***

(206) (*a*) Describe briefly a water-pressure reducing valve. (*b*) I have been told that a blacksmith's anvil is made from seven forgings welded together; why is it not made from one forging? (*c*) What is the object of double helical or herring-bone teeth on gear wheels, and why will not straight teeth do in same place? W. T. C., New Castle, Cal.

Ans.—(*a*) See Home Study Magazine for January, 1897, in answer to Question No. 179 (*g*). (*b*) The faces and horns of good anvils are made of steel forgings which are welded to the wrought-iron body. We do not know why the number of pieces used in this building-up process should be seven instead of some other convenient number. (*c*) Herring-bone teeth run together more smoothly, owing to the fact that the teeth come together more gradually. Straight teeth *will* do in the same place, that is, they will do the same work; but, for large cast teeth, herring-bone teeth are sometimes preferable, because inaccuracies that would render straight teeth useless give no serious trouble with herring-bone teeth. Herring-bone teeth are not quite as strong, however, as straight teeth of the same pitch.

***

(207) I have been called upon to repair a lift pump that has not given satisfaction since being put in position. It is placed over a well 26 feet deep, having a depth of water equal to about 3 feet. The end of the suction pipe is 8 inches under water, and it is 18 feet between the water and the piston cylinder. The cylinder is an iron one (not being brass lined I mean), and the piston leather fits snug. The valve seeks a brass seat and works a little stiff. The suction pipe is $1\frac{1}{4}$ inches and is of galvanized iron below the cylinder. I could find no flaw or crack in pipe and the pipe is threaded together very tight. I got water in a free stream from the pump, but the handle would start and raise as soon as left free, and would continue to do so until it found the starting point of the up-stroke. What causes this; is it a leak in valve at seat, or what? F. W. R., New London, Ohio.

Ans.—It is impossible to tell the real cause of the action you speak of without knowing how the pump rod and handle are connected. It is probable, however, that the weight of the pump rod and piston is great enough to more than balance the weight of the pump handle, and the action of this weight is what causes the handle to rise. If such is the case it is no indication of a leak or other imperfection in the action of the pump.

***

(208) I shall be glad if you will settle the following dispute: A argues that a 24″ x 48″ engine which makes 75 revolutions per minute when the pressure of steam is 80 pounds gauge, will not change if the steam pressure is increased to 100 pounds; B claims that the speed will change. Who is right?
W. H. E., Lincoln, Neb.

Ans.—You refer, we suppose, to an engine fitted with a governor. If so, A is right. The tendency of the incoming higher-pressure steam would be, of course, to increase the speed, but the governor then comes into play, either to partly close the throttle or else decrease the cut-off. A governor can maintain a practically constant speed when the load becomes lighter, and it can therefore deal equally well with the case of increased steam pressure, for this is, in effect, exactly the same thing as decreasing the load.

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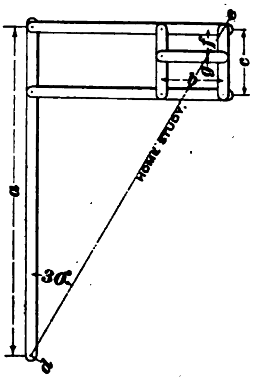
(209) (*a*) The accompanying figure represents an indicator-reducing motion, in which d is to be connected to the cross-head of the engine, e to be stationary, and g to make connections with the indicator card. For any stroke, or, to take the case in point, for a 72-inch stroke, how will I find the length of a and the width c, of the two crosspieces, and how shall I locate the crosspiece f from e to give the indicator card any desired size? (*b*) What make of indicator would you advise me to purchase for engines running from 200 to 275 revolutions per minute? P. S. D.
Doylestown, Pa.



Ans.—(*a*) Within reasonable limits, the dimensions a and c are of no consequence. You may make a from 6 to 9 feet and c about $\frac{1}{8}$ of a. The point g is determined from the proportion $\frac{eg}{ed} = \frac{\text{length of card}}{\text{length of stroke}}$; thus, with 72-inch stroke and a card 3 inches long, $eg = \frac{3}{72}ed = \frac{1}{24}ed$. Also, $f = \frac{1}{24}a$, f being measured on a line parallel to a. For a card 4 inches long, $eg = \frac{4}{72}ed = \frac{1}{18}ed$, and $f = \frac{1}{18}a$. The point g must be taken on the line joining e and d. (*b*) The Tabor, Crosby, or Thompson.

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(210) On pages 96-97 of your Mechanics' Pocket Memoranda it is stated that carbonate of soda is the best remedy for incrustations of carbonate of lime or sulphate, or both combined. Will you please inform me how much should be used for a boiler using 40 gallons of water per hour, and how often and when it should be used—while running gradually, all the time, or at the close run, and let remain in boiler mixed with the water? A. T. L., Steeleville, Ill.

Ans.—It is quite impossible to answer this question off-hand. You must have a chemical analysis of the water made. The amount of mineral impurities present will regulate the quantity of soda to be

introduced into the boiler. Too much soda is injurious; it will cause foaming and also affect the surface of the gauge glasses. Begin with ¼ pound of caustic soda daily, and increase until you get a good working proportion.

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(211) I am a practical student of plumbing. A local examining board asks the following question. "What are the causes of capillary attraction in traps? Describe its operation." I cannot answer this with any satisfaction to myself. Can you help me out?
J. McA. A., Pittsburg, Pa.

Ans.—The cause of capillary attraction in traps, or in anything else for that matter, may be referred to the mutual attraction of the liquid molecules for each other and the attraction between these molecules and solid bodies. We might go on here to describe capillary phenomena between different liquids and solids, but the one most important in this particular case is that which takes place by the introduction of some kinds of solid matter in a water-sealed trap in a plumbing system. Now, there are many different ways in which capillary attraction can affect traps, and perhaps the following is as good a representation as we can find, being simple and quite liable to occur in plumbing work. The above figure shows a common, every-day connection between a wash basin *a* and a 1¼-inch lead S trap *b*. A piece of worsted or cotton twine *c* has caught over the strainer bars at the basin outlet and the loose end hangs down into the waste pipe. Water flowing from the basin has worked the string through the trap, but cannot wash it down into the drainage system. This string acts like a small siphon tube, and siphons the water out of the trap until the seal is broken. The figure shows how the water runs off the end of the string, drop by drop, and it also shows how sewer gas can enter the building through the trap thus unsealed. The direction of the sewer gas is shown by the arrows. The force which lifts the water in the trap and discharges it over the outlet ridge, thus depositing it in the waste pipe, is simply that due to the attraction between the liquid and the surfaces of the many fibers in the string, or, as it is commonly understood, capillary attraction, and the water is siphoned out of the trap because the tail end of the string is lower than the water in the trap.

***

(212) What is action and the advantages of a compensating cylinder on pumping engines?
F. H. B., Rouse, Cal.

Ans.—In an ordinary direct-acting pumping engine the steam cannot be used expansively, since the pressure on the steam piston must be nearly constant in order to overcome the constant resistance of the pump plunger. If a flywheel is used, it will store up energy during the first part of the stroke to be given out during the latter part; this will permit the steam to be cut off at an economical point in the stroke, and at the same time furnish a nearly steady force to drive the pump plunger. Direct-acting pumps have some advantages over flywheel pumps for certain classes of work, and the compensating cylinder is used in order to do the work of the flywheel, and so make them more economical in their use of steam. During the first half of the stroke, when the pressure in the steam cylinder is the greatest, the compensating cylinder acts to compress the air in an air chamber, thus storing up a part of the energy developed by the steam, during the latter part of the stroke, after the steam has been cut off and the pressure acting on the steam piston reduced in consequence of its expansion, the air that has been compressed acts through the compensating piston to assist the steam.

***

(213) (*a*) Please give a good preparation for tempering soft steel; also a good process for annealing hard tool steel. (*b*) Where can I get a good treatise on gear cutting? G. T. K., Kings Mountain, N. C.

Ans.—(*a*) The grade of steel generally known as *soft steel* cannot be hardened or tempered. To anneal tool steel, heat it red hot, then bury it in either slaked lime or wood ashes and allow it to cool. (*b*) We know of no book devoted to gear cutting. Write to the Brown & Sharpe Mfg. Co., Providence, R. I. They publish a book which includes much good advice on gear cutting. George B. Grant, Lexington, Mass., also writes much on gears and gear cutting, write him too.

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(214) (*a*) What is an inspirator, and how does it work when forcing or pumping water into a boiler? (*b*) What is the lowest pressure of steam it will work with? (*c*) Is it similar to, and what advantages has it over, an injector? (*d*) What is the pressure of the atmosphere per square inch, carried to seven decimal figures, and what is the height of a column of mercury equal to such pressure? (*e*) What is the derivation and pronunciation of the word *adiabatic*, which I am unable to find in Webster's Unabridged and two other dictionaries?
G., Northwest Territories.

Ans.—(*a*) An inspirator works on exactly the same principles as an injector, the only difference being in the arrangement of the parts. The action of injectors and inspirators is explained in an article in Home Study, September, 1896. (*b*) The pressure with which an inspirator will work depends on its construction. Injectors are made that use the exhaust steam from the engine to feed the boiler. (*c*) See answer to question (*a*). (*d*) The pressure of the atmosphere varies for different altitudes, temperatures, degrees of moisture, etc. At the level of the sea, and a temperature of 32° F., the pressure is approximately 14.69 pounds per square inch, this being a generally accepted average value, determined from a great number of different observations. The height of a column of

mercury corresponding to this pressure is 29.92 inches. (*c*) Adiabatic is derived from the Greek *a-dia-batos—not to be passed over.* It is pronounced *ad-e-a-bat-ic*, with a slight accent on the last syllable, and a heavier accent on the next to the last syllable. *Adiabatic expansion* means expansion without the transmission of heat to, or from the expanding body. If, for example, steam is allowed to expand, its temperature will fall; but, if the expansion is adiabatic, no heat will be given up to or taken from the walls of the vessel containing the steam; such expansion is never obtained in practice.

* * *

(215) If a hole 2 feet in diameter is bored transversely through a 2-foot shaft, how many cubic inches of metal are removed? R. J. D., Canton, O.

ANS.—Let O be point of intersection of the cylinders; cut the cylinders by a plane parallel to their axes, let OP be perpendicular to this plane, and let $OP = x$. The intersections of this plane with the cylinders form a square whose side is:

$$c = 2\sqrt{R^2 - x^2}.$$

Therefore, area of this square $= 4(R^2 - x^2)$.

Hence, volume =

$$\int_{-R}^{+R} 4(R^2 - x^2)dx = \left[_{-R}^{+R} 4(R^2 x - \frac{x^3}{3}\right] =$$

$$8R^3 - \tfrac{8}{3}R^3 = \tfrac{16}{3}R^3.$$

Putting $R = 1$, we find volume removed $= \frac{16}{3} = 5\frac{1}{3}$ cubic feet.

* * *

(216) Why do some railroad-car wheels make a loud humming sound, while others do not? I notice that as a general rule it is the new trucks that make the noise. J. G. K., Forked Deer, Tenn.

ANS.—The fact you mention has not come within our notice. When the wheels are new the flanges are of full contour, and there is therefore a certain amount of rubbing on the sides of the rails—more, at any rate, than will obtain when the flanges are worn. This, together with the fact that everything about a new truck is also more or less *snug*, may possibly account for the phenomenon.

* * *

(217) Please answer the following. A ship is about to be launched. (*a*) Please tell me under which of the three following conditions she would be most retarded and least retarded, after she enters the water: no propellers on; propellers fastened to shaft and allowed to turn freely; propellers fastened to shaft, but locked and not allowed to turn. (*b*) What is the cause of the pitting or corroding of the tips of propeller blades? (*c*) Are you prepared to answer general questions on naval architecture?
H. P. W., Seattle, Wash.

ANS.—(*a*) We are not aware of any experiments having been made in this direction. At any rate, the retardation due to the propeller will be infinitesimal. (*b*) No satisfactory answer to this question has ever been given. (*c*) No; such questions entail far too much labor to be answered through the Answers to Inquiries columns of a magazine.

(218) (*a*) What is the difference between hydraulic and Portland cement? (*b*) Which have the greater holding power, cut or wire nails? (*c*) What is the freezing point of glycerin? (*d*) Which is the better, black- or cream-colored fireclay?
W. T. C., New Castle, Cal.

ANS.—(*a*) Portland cement is hydraulic cement, so-called because it has the property of setting in water. There are, however, two general classes of hydraulic cement, namely, Portland cement and natural cement; the latter is also called Rosendale, American, and Roman cement. All hydraulic cement consists, essentially, of lime and clay intimately mixed, thoroughly burned, and finely ground. The Portland cement is an artificial mixture, in such proportions as experience has shown to give the best results. Natural cement is made from the natural limestone. (See HOME STUDY, April, 1896, article entitled "Hydraulic Cements.") (*b*) Cut nails have considerably greater holding power than wire nails. (*c*) Pure glycerin solidifies at 40° C. to a gummy mass, which melts at 17° C. (*d*) The best fireclay consists of a mixture of 85 per cent. of Chinese kaolin and 15 per cent. of silica as quartz. The composition of kaolin is:

SiO_2	50.5
AlO_3	33.7
H_2O	11.2
Fe_2O_3	1.8
MgO	0.8
Alkalies	1.9
	99.9

It can be colored black by adding to the mixture of kaolin and quartz some black lead.

* * *

(219) (*a*) Will you give me information in regard to the best method of polishing ebony? (*b*) Also where I can procure a piece of ebony?
E. C., College Park, Md.

ANS.—(*a*) To polish ebony or other close-grained wood, wrap a piece of cotton cloth around a wad of plain cotton and saturate it with shellac varnish. Rub the previously sandpapered ebony surface with this cotton pad, lubricating it, if necessary, with a drop of raw linseed oil applied to the surface of the rubber. Let this surface dry for 24 hours and repeat the operation with a new rubber, previously sandpapering, if necessary, to remove any unevenness. To finish the surface, moisten a clean cloth with a few drops of alcohol and rub briskly for a few minutes. (*b*) Ebony may be procured from Uptegrove & Co., East Tenth Street, New York City, or any of the leading piano manufacturers.

* * *

(220) (*a*) How can latitude and longitude be determined by an observation on Polaris without waiting for culmination or elongation? (*b*) How can the azimuth of Polaris be determined for any hour? (*c*) Can a table be had showing the azimuth of Polaris for each day in latitudes north of 50°?
X Y Z., Cedar Rapids, Ia.

ANS. (*a*) Polaris is not used for determining longitudes. To find latitude by an observation on Polaris, or any other star, at any time, note the time of observation; reduce it to sidereal time and then to degrees, remembering that 1 hour = 15 degrees, take star's right ascension from Nautical Almanac. Then, have angle of star $= H =$ (*sidereal time*) (*right ascension*). Measure altitude h of the star; correct it for refraction, (see HOME STUDY MAGAZINE, May, 1898, Answers to Inquiries, No. 158), and subtract result from 90°. Then, $90° - h = z$ = zenith distance. Take declination d from Nautical Almanac. Then, if l is the latitude of the place, $\sin h = \sin d \sin l + \cos d \cos l \cos H$. An easy method for solving this equation for l is given in the number of HOME STUDY just referred to. (*b*) The

azimuth A for any latitude is given by the formula,

$$\sin \tfrac{1}{2} A = \sqrt{\frac{\sin \tfrac{1}{2}(z + l - d) \cos \tfrac{1}{2}(z + l + d)}{\cos l \cos z}}.$$

If l is not known, it may be computed as explained above. (*c*) We do not happen to have a table of this kind at hand. Ordinary American books on surveying give azimuths of Polaris between latitudes 30° and 50° only, these being about the limits between which this country lies. European books give azimuths for higher latitudes, and the same are given, if we remember well, in some Reports of the U. S. Coast and Geodetic Survey.

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(221) (*a*) How can I make a good toning solution? Also a good developing fluid? Both the above for photographic work.
J. B. B., Fredericksburg, Va.

ANS.—All plates or printing-out papers give the best results when developed or toned in a solution prepared according to their accompanying formulas. A good all-around toning bath may be made as follows:

A.—Chloride of gold	15 grs.
Water	37½ oz.
B.—Borax	150 grs.
Tungstate of soda	600 grs.
Water	37½ oz.

Mix equal parts of *A* and *B* for use, and tone prints till slightly purple, then wash and fix in a 20-per-cent. solution of hyposulphite of soda. A good developer may be prepared by mixing

Hydroquinone	240 grs.
Sodium sulphite (powdered)	2 oz.
Potassium carbonate	2 oz.
Water	32 oz.

Fix in a hyposulphite-of-soda bath as above.

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(222) I want a traction engine about 15 horsepower to do regular farm work, such as plowing, threshing wheat, hauling, etc. Can you tell me where and at what price I could get such an engine?
J. B., Fredericksburg, Va.

ANS.—The following firms are builders of traction engines: Nichols & Shepard, Battle Creek, Mich.; J. I. Case Machine Co., Racine, Wis.; C. Aultman & Co., Canton, O.; Guar, Scott & Co., Richmond, Ind. The price may vary from $1,000 to $1,500.

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(223) If an automatic feedwater injector that works well when the steam pressure is 90 pounds per square inch refuses to lift and deliver when it is fed with steam at a pressure *greater* than 90 pounds, what is the probable cause of the trouble?
E. F., Fort Washington, Wis.

ANS.—Write to the makers and ask them. There are so many different kinds and designs of injectors that we cannot attempt to give you any assistance without being on the spot.

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(224) Will you please inform me how to calculate the following: A boiler containing 3,000 pounds of water and 22 cubic feet of steam space has the furnace so banked that the pressure remains steadily at 65 pounds per square inch by the gauge; the throttle or stop-valve being opened for the space of one minute, the pressure is found to have fallen to 64 pounds per square inch. What has been the approximate evaporation during that time?
V. W. T., Cascade Locks, Ore.

ANS.—The fall of pressure from 65 to 64 pounds per square inch causes a decrease of about 87° F. in the temperature of the water. (This may be found from steam tables.) The water gives up, therefore, 3,000 × .87 = 2,610 British thermal units. At this pressure the latent heat of steam is about 895 B. T. U., that is, 895 B. T. U. are required to evaporate 1 pound of the water. Hence, the weight of water evaporated is 2,610 ÷ 895 = 2.92 pounds, approximately. It is assumed that the heat given to the boiler by the banked fire is so small that it may be neglected.

***

(225) (*a*) Kindly furnish a rule for the proportioning of cylinder flanges and bolts such as I illustrate in Fig. 1. (*b*) Also furnish a rule for the proportioning of pulley hubs. (*c*) Will this last rule do for flywheel hubs too?
H. C., Brooklyn, B., N. Y.

ANS.—(*a*) If p is the pressure in the cylinder in pounds per square inch, and D the diameter of the cylinder in inches, the dimensions of the flange and bolts may be made as follows: thickness of

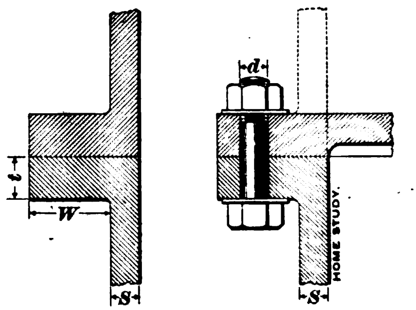

FIG. 1.

cylinder $S = .0003\, p\, D + \tfrac{3}{8}$ inch; if p is less than 100 pounds per square inch, make the thickness $S = .03\, D + \tfrac{3}{8}$ inch. Make the number of bolts n such that the space between two consecutive bolts shall not be greater than 4½ inches.

The diameter d of bolts $= \dfrac{D^2 P}{5100\, n}$.

The thickness t of flange $= 1\tfrac{1}{4}\, S$.

The width W of flange $= 2\tfrac{1}{4} d$.

(*b*) If B is the breadth of the pulley rim, R the

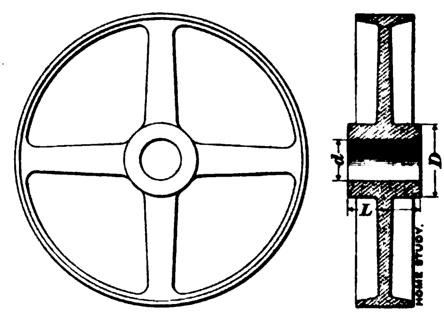

FIG. 2.

radius of the pulley, and d the diameter of the shaft, the diameter D of the hub may be made equal to $d + \dfrac{(B + R)}{16} + \tfrac{1}{4}$ inch. The length L of the hub may be made equal to B. (*c*) The proportions of the hub of a flywheel depend on the weight of the wheel and the variations in its speed. A rough rule for the hub of a flywheel is to make the diameter D of the hub twice the diameter d of the shaft, and the length L of the hub 1⅝ times the diameter d of the shaft; i. e., $D = 2\, d$, and $L = 1\tfrac{5}{8}\, d$.

(226) I wish to float a substance in a liquid—the liquid to be as cheap as possible, but not an acid nor very poisonous to handle. The specific gravity of the substance is 1.33. Of course the chemical must dissolve in water, and have a specific gravity of from 1.36 to 1.40. L. A. O. G., Brookwood, Ala.

ANS.—A solution of "soluble glass" (sodium silicate) will answer the purpose.

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(227) Will you please explain the advantage, if any, in making the vanes of a windmill of a curved section? There are windmills here with the concave surface of the vanes towards the wind, and others with the convex surface towards the wind. I suppose if one is right the other must be wrong. I may say that I have examined the wheels and they are put together as they were intended to be by the makers. No mistake has been made in the erection.
F. D., Johannesburg, South Africa.

ANS.—We see no good reason for the use of curved vanes. A flat vane, twisted so as to conform approximately to the form of a true helix or screw, will give excellent results. In choosing between vanes with convex or concave surfaces to the wind, the latter will undoubtedly give the best results. The curved vane is the outcome of a fancied analogy between the windmill and the screw propeller, while, in fact, there is considerable difference in the operation of the two. An article on windmill construction will be found in the March, 1898, number of HOME STUDY MAGAZINE.

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(228) (*a*) Can you give me an idea what the area of the inlet and exhaust ports of a gas engine should be, constructed on the principle of the Day type, as described in HOME STUDY MAGAZINE February, 1898? Take, for example, an engine having a 3½-inch cylinder and a 3½-inch stroke, and give the sizes of the ports. (*b*) Is there any rule for calculating the size of these ports with reference to the diameter of the cylinder and the length of stroke? (*c*) In the Day engine I take it that the lower edge of the exhaust port is horizontally opposite the top edge of the inlet port. Am I right? (*d*) Would the gas-engine card published in the February, 1898, number in answer to question 8 be an average card for an engine of the Day type?
G. H. J., Sparrow's Point, Md.

ANS.—(*a*) Make the area of the inlet port 1¼ square inches, and that of the exhaust port 1⅝ square inches. (*b*) A good general rule is to make the area of the inlet port 12%, and that of the exhaust port 16%, of the piston area. (*c*) See answer to question 117 in HOME STUDY MAGAZINE for April, 1898. (*d*) A card from the Day engine would be very similar to the one referred to.

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(229) The following is an extract from a newspaper article describing an explosion in a brewery: "By the bursting of a compressed-air pipe in the ice-machine room of George Ringler & Co.'s brewery, at 213 East Ninety-First Street yesterday, Chief Engineer Carl Hoening, 51 years old, of 315 East Ninety-Third Street, was killed, and Adolph Schenken, 23 years old, of 241 East Eighty-Eighth Street, received several severe wounds, and is at the Presbyterian Hospital. The pipe, which is 12 inches in diameter, about an inch thick, and 14 feet in height, connects the ammonia tank with one of the engines. A number of heavy-pressure tests had been made, and Hoening was submitting the pipe to a greater test when it exploded. A shower of heavy pieces of metal fell in all directions. Two large pieces struck Hoening squarely on the top of his head crushing in his skull. By almost a miracle John Hoening, the son of the dead man, escaped injury. He was standing by his father watching the test and assisting him. Every window in the room was shattered, and the pipes, large and small, with which the roof and walls are lined, were snapped as though they were pieces of clay. The machinery in the room was torn and broken in many places, and in some instances flying iron missles went through sheet iron as if it had been pine board." (*a*) Is it not probable that this explosion was caused by oil in the pipes? Will you kindly explain how these explosions occur in refrigerating machinery? (*b*) I have noticed in New York a number of gas engines fitted with a rubber bag, which is usually connected just over the engine. Will you kindly explain its use and state how far the bag should be from the exhaust pipe of engine to prevent all danger of an explosion?
E. S. A., Brooklyn, N. Y.

ANS.—(*a*) The explosion may be due to either of two causes: First, carelessness in testing, and rupture due to excessive pressure; the article reading, "and Hoening was submitting the pipe to a greater test when it exploded." Second, an explosive mixture composed of hydrocarbons, liberated by the heat of compression from the lubricating oil, and the oxygen of the air. The oil used for lubricating ice-machine cylinders is a mineral oil, having a low, cold test, but not a very high fire test. This oil gives off various hydrocarbon gases at comparatively low temperatures. These are highly explosive when mixed with air. If insufficient jacket water is circulated, or if the compressor is of the Linde or wet-compression type, care must be exercised by running slow, not to develop a temperature high enough to explode the mixture. The flame of a lamp is sometimes used to detect a leak; this is liable to ignite this mixture. (*b*) The purpose of the gas bag is fully explained on page 9 of HOME STUDY MAGAZINE, February, 1898. There are two conditions under which an explosion can occur in this bag. One condition is the presence of sufficient air mixed with the gas in the bag to produce an explosive mixture; the other, expansion of the gas in the bag, due to confining the gas without opportunity of escape, and rise of temperature. An explosion in the first instance would require the ignition of the mixture; in the second, exposure to unusual heat. The formation of an explosive mixture in the bag may be said to be exceedingly improbable. The overheating of the bag from the exhaust pipe can be avoided by placing the bag 2 feet or more from the exhaust pipe.

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(230) Can you tell me (*a*) how to polish horn? (*b*) how to remove ink stains?
J. B., Fredericksburg, Pa.

ANS.—(*a*) Various methods are in use. A felt polishing wheel can be employed, using finely-ground pumice with water, finishing off with rottenstone. Or you can scrape the parts quite smooth, and then rub down with very fine sandpaper, followed by powdered charcoal and water, applied on a bit of felt. Then use rottenstone or putty powder and polish finally with chamois leather dampened with sweet oil. Or you can finish off by rubbing in subnitrate of bismuth with the bare hand. (*b*) If the stains are in the hands, use lemon juice. If in clothes or in other fabrics, lemon juice will sometimes prove effective. If not, try a solution of oxalic acid (1 part acid to 2 parts water). Rub in well with a soft rag. A very good remedy is pyrophosphate of soda, which does not injure the fiber of the cloth. First put a little tallow in the ink stain and then wash in a solution of the above soda, until both ink and tallow have disappeared.

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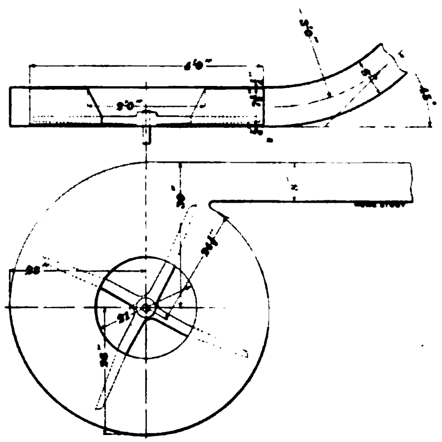
(231) Please inform me whether there are any objections to the use of piston igniters in gas or gasoline engines; and if so, what they are?
A. R. R., Winona, Minn.

ANS.—We do not know what you mean by a "piston" igniter. There are several igniters to which this name might be applied.

(232) I enclose a sketch of a fan. (*a*) Please give the proper proportions to get the largest volume of air through it, and have a keen, stiff blast through the delivery pipe. (*b*) If the angle of delivery pipe is changed to 40°, and the radius of curve is changed from 3 feet to 2 feet, will the capacity of the fan be increased or decreased, length of the pipe remaining the same, 12 feet? C. W. Q., Bloomington, Ill.

ANS.—(*a*) Assuming that by a "keen, stiff blast" you mean a velocity of air through the delivery pipe of about 150 feet per second, the dimensions of the fan for your pipe should be about as given in the figure.



You will notice that the outer circumference of the casing, instead of being concentric with the fan shaft, is spiral-shaped, so as to gradually increase the area of the passage for the air toward the outlet into the delivery pipe. (*b*) It is probable the capacity would be decreased.

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(233) (*a*) Will you please explain the following strange behavior of an electric bell: There are times when, though I make the proper connection, the bell will not operate, no current passing through the wires for the time being; but the instant I press the hammer against the gong the current flows and the bell rings. It is an ordinary electric door-bell and is used for signaling purposes. Please explain the operation of the bell in detail. (*b*) What is the breaking strength of a ¼-inch six-strand (7 wires to the strand) crucible-steel wire rope; and what is the safe working strength?
G. W., Sand Coulee, Montana.

ANS.—(*a*) The adjustable screw, bearing on the spring of the armature, is not properly set. A detailed explanation of an electric alarm bell may be found on page 25 of the August, 1897, number of HOME STUDY FOR ELECTRICAL WORKERS. (*b*) For the best grade of crucible-steel wire, known as "plough-steel" wire, the breaking strength is about 66,000 pounds, and the safe working strength 13,000 pounds.

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(234) (*a*) Supposing I want to cut a bastard thread, say 8 threads to the inch, and having the sides of the thread cut to an angle of 7°, what width would I have to make the point of the tool, in order to cut the proper depth and have the top and bottom of the thread exactly the same? (*b*) Suppose I have a piece of stock 5¼ inches long which I wish to turn to a taper ¾ inch to the foot, how far over would I want to set the dead center of my lathe?
F. H. F., Springfield, Mass.

ANS.—(*a*) Denoting the pitch of the thread by p, its depth by d, and the number of the degrees of the angle of the thread by n, the width w of the tool may be figured from the formula $w = \frac{1}{2}p - (.0174533\, n + .0000018\, n^3)d$. In your example, $p = \frac{1}{8}''$ and $n = 7$, and if you make $d \times \frac{1}{2}p = \frac{1}{16}''$, you get $w = \frac{1}{16}'' - (.0184533 \times 7 + .0000018 \times 7^3)\frac{1}{16} = .0548''$. (*b*) See answer to question 362, in HOME STUDY MAGAZINE for September, 1897.

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(235) Can you inform me if there is any method of welding or repairing cracks in locomotive fireboxes, other than by sewing with plugs or patching?
A. A., Macon, Ga.

ANS.—We do not know of any other method that is in practical use. There is such a thing as electric welding, and, we believe, attempts have been made at using it for repairing boilers, etc., but we should be very skeptical about any welding process for cracked fireboxes.

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(236) Will you kindly tell me if there are any books published on the designing of machinery for refining beet and cane sugar—or either; also, the address of parties I can get such machines from?
W. O. D., Cold Spring, N. Y.

ANS.—We do not know of any book treating upon this subject. Most of the machinery used in sugar refining is made in Germany. Write (in English) to Zimmerman & Son, Halle an der Saale, Germany, or to Gruson's Maschienen Werke, Magdeburg, Germany, who will furnish you with all the information concerning price, etc. you desire.

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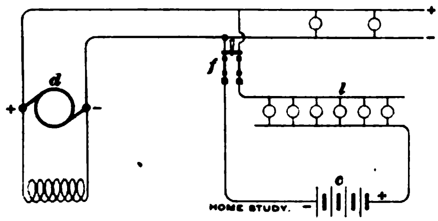
(237) (*a*) I am running a T. H. arc machine—25 lamps. It is necessary, in order to feel the bearing nearest the leather belt, to approach my elbow within 3 or 4 inches of the pulley rim, and the static charge to my elbow is then so severe that I hate to touch the bearing. The machine is so arranged that there is no other way of getting at the bearing. How can I conduct the discharge away? (*b*) Would a board covered with tin and driven full of nails, placed within 3 inches of the belt bottom—the wire being led to earth—be of any use? (*c*) An arc machine and an incandescent machine are within 4 feet of each other and are running nicely. Are they dangerously close together? They get their motion from the same engine; their belts are 12 inches apart, as in sketch enclosed. (*d*) Can you recommend or send to me a good book on the diseases of arc machines and arc lamps, with their remedies? (*e*) I wish to charge 4 storage cells from the dynamo that is running lights after 9 P. M. Most of the load is off the machine and I wish to charge storage cells while running the other lamps. Please explain by means of a diagram how I can do this.
C. J. S., Oakland, Cal.

ANS.—(*a*) The frame of the machine may be grounded, but this is not advisable, although it is recommended by some station managers. In your second question, you have suggested a far safer and more reliable means of obtaining the same result. (*b*) Yes; this will work well if the wire has a good ground. The sharp points increase the efficiency of the apparatus. Another way would be to connect the machine frame to the earth through a heavy pencil mark on a piece of hard, dry wood. The static charge would thus be enabled to escape to the earth, and the insulation would not be subjected to any increased electrical stress. (*c*) Electrically, no; provided the machines are on insulating bases, and are located in a dry place. The belts may be considered dangerously close, because, if one belt is thrown off by an overload, it may become entangled with the other, and possibly wreck the dynamo, and the engine also. Such a catastrope can be averted by erecting belt guards. (*d*) You can get more information from trade catalogues than from books, on the construction of arc lamps. You can, however, obtain more satisfaction from the lamp itself, if you devote two hours to taking it to pieces, putting it together, tracing the circuits, following the mechanical motions, observing the magnetic effects, etc.,

than by studying a book a much longer time. The dynamo cannot be so thoroughly comprehended without reference to some good authority. "Dynamo-Electric Machinery," by S. P Thompson, discusses the theoretical and practical points of the construction and management of direct- and alternate-current dynamos and motors. This is a very complete work. (*c*) Knowing the charging current, select the required number of lamps of proper voltage, so that, when connected in multiple across the mains, they will permit the required current to pass. Let us suppose



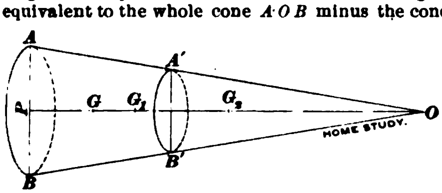
that the dynamo furnishes a direct current at a constant E. M. F. of 120 volts, and that the greatest charging current allowed for the cells is 3 amperes. Putting six 110-volt lamps in parallel, as indicated at *l* in the sketch, the group is connected to the mains of the dynamo *d* through the combined fuse and switch *f*. This fused switch is highly advisable, in order that the circuit may be protected. The secondary cells *c* are now connected in series and in circuit, as shown. When the dynamo is running and the switch *f* is closed, a current of almost exactly 3 amperes will pass through the cells *c*. Great care must be taken in connecting up, noting that the positive terminal of the battery is connected to the positive terminal of the dynamo.

***

(238) Please answer the following: (*a*) Suppose a log 10 feet long, 14 inches in diameter at large end and 9 inches at small end, to be carried by three men. With one man at small end, where would the other two take hold, opposite each other, in order that each should carry an equal weight? (*b*) In the table of dry measure there are 8 gallons in 1 bushel, 231 cubic inches in a gallon, and 231 × 8 = 1,848 cubic inches in a bushel. In another rule I find 1 bushel contains 2,150.4 cubic inches. Please explain.

J. H. G., St. Louis, Mo.

ANS.—(*a*) The log is a frustum of a cone, whose length is easily found to be 336 inches. The log is equivalent to the whole cone *A O B* minus the cone



A′ O B′. The center of gravity of a cone lies on the axis and is one-fourth of the altitude from the base; hence, if G_1 and G_2 are the centers of gravity of the cones *A O B* and *A′ O B′*, we find $PG_1 = 84$, and $PG_2 = 174$. Now the volumes of two similar cones are proportional to the cubes of the diameters of their bases. Hence, if *G* be the center of gravity of the frustum *A B B′ A′*, we have

$$PG = \frac{84(14)^3 - 174(9)^3}{(14)^3 - (9)^3} = 51\tfrac{177}{403} \text{ inches;}$$

hence, the distance of the single man from the center of gravity equals $120 - 51\frac{177}{403} = 68\frac{226}{403}$ inches. The two men must be half this distance, or $34\frac{113}{403}$ inches, from center of gravity. Therefore, they are $51\frac{177}{403} - 34\frac{113}{403} = 17\frac{64}{403}$ inches from big end of log. (*b*) The old English wine gallon, which is now the legal standard of liquid measure in the United States, contains 231 cubic inches. Legally it is defined as containing 58,372.2 grains of distilled water at its maximum density, the weighing being performed in air at 62° F., with a barometer pressure of 30 inches. This is identical with the old Winchester wine gallon. The United States standard of dry measure is the Winchester bushel, which contains 2,150.42 cubic inches. It is called the Winchester bushel because the ancient standard bushel measure of England was preserved in the town hall at Winchester. This was the English standard bushel from Anglo-Saxon times until 1826, when the present British imperial measures were adopted. The present imperial standard gallon of Great Britain, for liquid and dry measure, contains 277.274 cubic inches; and, therefore, the imperial bushel contains 2218.192 cubic inches. Before the adoption of the present imperial standards, there were many gallons in England. A statute of 1452 defined a gallon, for liquid and dry measure, as containing 8 pounds troy of wheat. Henry VII had a standard gallon made according to this definition, which was supposed to contain 272¼ cubic inches, but its correct capacity was 274¼ cubic inches. A statute of 1697, defining dry measures, intended to conform to this standard, but the corn gallon constructed under this statute was found actually to contain 268.6 cubic inches, which gives a bushel of 2148.8 cubic inches, and differs very little from our bushel.

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(239) Please point out the error in the following example to prove 1 = 2. Let $a = x$: therefore, $ax = x^2$. Subtracting a^2 from both members, $ax - a^2 = x^2 - a^2$. Factoring, we have $a(x-a) = (x-a)(x+a)$. Dividing by $(x-a)$ we have $a = x + a$. But $x = a$; therefore, $a = 2a$, or $1 = 2$.

W. E. W., San Francisco, Cal.

ANS.—If *A*, *B*, and *C* are any mathematical expressions, and if $A \times B = A \times C$, then, if *A* is not zero we can divide both members of this equation by *A*, and we will have $B = C$. But, if *A* is zero, *B* and *C* are not necessarily equal; thus, we know that

$$2{,}956{,}875 \times 0 = 1 \times 0,$$

for each member of this equation is equal to zero; dividing both members by 0, we would have

$$2{,}956{,}875 = 1.$$

Hence, when we divide the equation $A \times B = A \times C$ by *A*, we have that either *A* is zero, or $B = C$; but if *A* is zero we do not know whether *B* and *C* are equal or not. The equation $a(x-a) = (x-a)(x+a)$, when $x = a$ is simply $a \times 0 = 0 \times (x + a)$. The fallacy consists in dividing by 0, and writing $a = x + a$.

***

(240) Will you kindly explain how prints are made from copperplates, and how the ink is put on such plates?

F. D. H., Jersey City, N. J.

ANS.—The following was extracted from the "Encyclopaedia of Printing": "*Plate Printing.*—This term is now commonly applied to the description of printing formerly called copperplate printing, the name having been changed in consequence of the general substitution of steel for copper plates. It differs radically from typographical printing in the fact that the hollows of the plates used, instead of its elevations, are reproduced on the printed sheet, the philosophy of the process being that pressure on the elasticity of cloth blankets forces moist paper to enter the indentations of a plate and take up all the black ink from it. The surface of the plate, after being supplied with a more liquid ink than that used in typographical printing, is carefully cleansed before each impression, so that no ink may be deposited upon the paper printed, except that which sinks into

the depressions of the plate. Plate or copperplate printing continues to furnish the highest type of artistic excellence, no other system of printing with black ink only being capable of producing specimens equal to first-class mezzotint and steel engravings."

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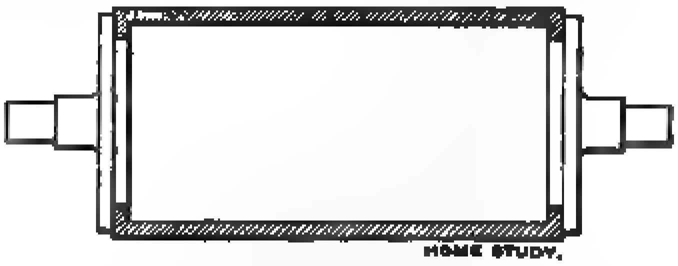
(241) If I take a hollow cylinder, as in sketch, and supply it with steam, condensation will take place and the water will lie at the bottom of the cylinder. How can I determine the velocity at which the cylinder must be rotated in order that the condensation water shall cover the inside surface of the cylinder to an even depth?

F. P. K., Wilmington, Del.

ANS.—The number of revolutions per minute would have to be infinite to produce such a result. In other words, no velocity, however high, will be sufficient to



cause the water to cover the surface at an even depth. It is doubtful if the velocity at which the water would cover the surface at an *uneven* depth can be found by mathematical analysis.

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(242) Suppose I were going to bore a hole to suit a $2\frac{1}{4}$-inch shaft or axle, a working fit, and were to set my outside calipers for the shaft and from them set my inside calipers; the inside calipers should have a little play or shake in the hole. I should like to know what that play or shake should be. Is there any rule allowing so much to the inch, as the size of the shaft or axle increases or decreases? H. T., Pueblo, Col.

ANS.—The practice in regard to the play which a shaft should have in its bearing is not uniform, and depends to a great extent on the kind of machinery a particular workshop is accustomed to turn out. For very accurate machinery the play for small shafts up to 3 inches is as little as two-thousandths of an inch, that is one-thousandth all around; for very large shafts as much as five-hundredths. Speed and facility for lubrication are also important factors. A rule expressing a simple relation between diameter of shaft and play cannot be given.

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(243) (*a*) How is it that sound travels faster in wood than in air? In your statements upon sound, in HOME STUDY MAGAZINE, January, 1898, you say that the velocity depends upon the elasticity and density of the medium. Air is less dense than wood, but more elastic. (*b*) How can the crusting on the inside of an iron water tank be removed and prevented? (*c*) The tank only half fills with water. Is this caused by a faulty ball valve or what?

G. H. S., Brooklyn, N. Y.

ANS.—(*a*) The reason sound travels more quickly through wood than air, though air is more elastic than wood, is that the sound vibrations are limited to a certain space in the wood, and are restricted within the compass of a mass whose volume is vastly less than that of the practically boundless atmosphere. (*b*) We cannot very well give you advice without knowing the composition of the water you are using. We, however, want to draw your attention to two articles, one published in the February, 1898, number of HOME STUDY MAGAZINE, and the other in the March number of "Mines and Minerals," which may give you a clue how to prevent and remove the crusting in your water tank. (*c*) Your valve closes too soon. Bend the ball lever upwards, so that the valve will not close till the ball (and, therefore, the water) has reached a higher level.

(244) I have occasion to use large quantities of water at a temperature of 45° F. This water has, of course, to be cooled. At present I use two cylinders 5 feet long by 1 foot in diameter; I use cylinders in preference to coils of piping, to obviate loss of pressure through friction and also for reserve supply. The cylinders are immersed in water in a wooden tank, the water entirely covering the cylinders. The water enters at a temperature of 70° F. The quantities of water used vary greatly, each operation using from 10 to 20 gallons in about 2 minutes. The number of operations per day is 25 and the number per hour never exceeds 5. As far as *results* go, I am satisfied with the arrangement I have, but I fear I use more ice than is necessary. (*a*) Would brine give better results? (*b*) What do you think of the idea of using one iron tank 2 feet 6 inches diameter and 7 feet long, putting ice inside it and drawing the water through the ice? (*c*) Could you suggest any plan by which I could use a small ammonia plant?

F. R., New York, N. Y.

ANS.—(*a*) We do not think that the use of brine will save ice, but it might enable you to cool a given quantity of water in a shorter time. (*b*) If you use the larger tank filled with ice the water, if left in contact with the ice for some length of time, will assume the temperature of the ice (32°). If you mean merely to allow the water at 70° to pass through the cylinder as it is being drawn off, it seems to us that the time of contact will be too short to lower the temperature from 70° to 45°. We do not see where the proposed scheme is an improvement on your present method. (*c*) You might use a small ammonia plant, arranged somewhat as shown in the accompanying figure. The vaporizing coil is placed directly in the water tank *D*, the liquid ammonia passing from the condenser *B* through the expansion valve *C*.

In order that the water might be kept at the desired temperature (45°), it would be necessary to either use it at regular intervals or devise some means of regulating the speed of the compressor *A*.

***

(245) (*a*) What instruments are necessary to equip an amateur meteorological observatory? (*b*) How should the observatory be built? (*c*) How should the instruments be arranged? (*d*) What book is there on the subject of meteorology that you would recommend? J. A. A., Andover, Ill.

ANS.—(*a*) A Robinson's anemometer, a standard rain gauge, either maximum and minimum thermometers or a registering thermometer, a sunlight recorder, a barometer, and a hygrometer. Most of these instruments are made in a variety of forms and sell at various prices. (*b*, *c*, and *d*) For the method of building and arranging an observatory we refer you to "American Weather," by Greeley (may be obtained from The Technical Supply Co., Scranton, Pa.). This is recommended as the best book on the subject for your purpose. You may also get some valuable information on the subject by writing to the United States Weather Bureau, Washington, D. C.

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AMSLER'S POLAR PLANIMETER.

Antonio Llano

METHODS FOR DETERMINING THE AREA OF AN IRREGULAR FIGURE—OBJECT AND ADVANTAGES OF THE PLANIMETER—ITS PRINCIPLE ELEMENTARILY EXPLAINED AND DEMONSTRATED.

SEVERAL methods may be used for the determination of the area of a plane figure. If the figure is a simple one, whose bounding lines follow an exact mathematical law or come under ordinary geometrical definitions, its area may be found at once by the rules of geometry. Triangles, circles, parallelograms, and parabolas are illustrations of figures of this kind. If the figure has an irregular outline, its area may be approximated in various manners, usually by subdividing the figure into parts sufficiently small to consider them as either triangles or trapezoids, according to the system of division used: steam-engine diagrams, bending-moment diagrams, and fields bounded by rivers or lakes are examples. The process of approximation, however, is sometimes exceedingly laborious, and in order to dispense with it, several instruments have been devised by which the area of any figure can be found with great accuracy and with almost no labor. Of these, Amsler's polar planimeter is the simplest and most convenient to use.

The instrument consists of a graduated arm $g\,h$ (Fig. 1) carrying a pointer d at one end, and clamped at the other end to a frame F, which has a groove, or socket, along which $g\,h$ can be made to slide by means of the thumbscrew f, thus adjusting the length of the arm to any desired distance. To the frame is pivoted another arm $i\,j$, movable about i, and carrying an anchor point e at its extremity. Finally, the frame rests on a wheel c whose axis $a\,b$ is horizontal. By a simple arrangement, the horizontal wheel l is made to register the number of whole revolutions of c, whenever the latter is made to roll. The wheel c itself is divided into 100 equal parts, and is provided with a vernier v by means of which one thousandth of a revolution can be read. When the instrument is in operation, it rests on the three points d, e, and w, and it is so adjusted that $g\,h$ and $a\,b$ are always in the same vertical plane.

FIG. 1.

In measuring the area of a figure, the anchor point e is fixed at some convenient point on the paper, while the pointer d is passed around the outline of the figure. This motion causes the wheel to revolve, owing to the friction between it and the paper; and from the number of revolutions, measured as stated above, the area in question is found, in the manner now to be explained.

In Fig. 2, the area $d_1\,d_1'\,d_2'\,d_2$, bounded by two concentric circular arcs and by two

radii, is to be determined by means of the planimeter. The angle $d_1 e d_1'$ is supposed to be "infinitely small." Let the instrument be placed with its anchor point at e and its pointer at d_1; the pivoted joint will then be at i_1, and the wheel at w_1. When the pointer moves from d_1 to d_1', the point i_1 will move in the arc of a circle to the position i_1', and the wheel will move to w_1', on $d_1' i_1'$ produced, so that $i_1' w_1' = i_1 w_1$. The angle described by

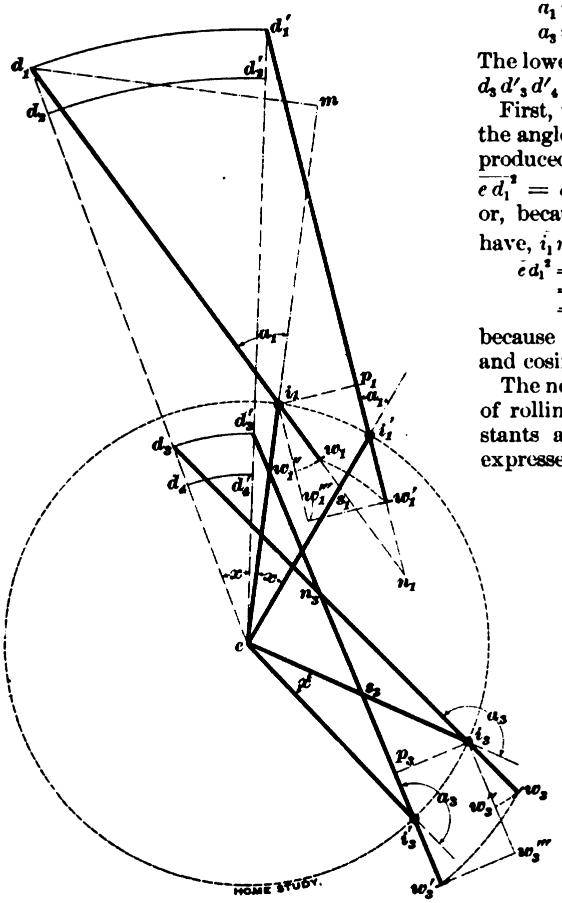


FIG. 2.

i_1 and by w_1 will, of course, be equal to the angle x through which the whole instrument has revolved. In moving from w_1 to w_1', the wheel generally rolls about its axis, the amount of rolling being read off the wheel itself and the vernier; and the problem now is to determine the relation between this rolling and the angle swept over by the pointer. The wheel is usually so graduated that, when it revolves in the direction of the hands of a clock (looking from w_1 towards d_1), the reading increases; and, of course, the reading decreases when the wheel turns in an opposite direction. We shall, therefore, consider clockwise rolling of the wheel as positive, and counter-clockwise rolling as negative.

Let

$$k = e i_1 = e i_1' = e i_3 = e i_3';$$
$$h = d_1 i_1 = d_1' i_1' = d_3 i_3 = d_3' i_3';$$
$$l = i_1 w_1 = i_1' w_1' = i_3 w_3 = i_3' w_3';$$
$$a_1 = \text{angle } e i_1 w_1 = e i_1' w_1';$$
$$a_3 = \text{angle } e i_3 w_3 = e i_3' w_3'.$$

The lower part of the figure relates to the area $d_3 d'_3 d'_4 d_4$, as will be explained further on.

First, to express $e d_1$ in terms of k, h, and the angle a_1. Draw $d_1 m$ perpendicular to $e i_1$ produced. Then, in the right triangle $e d_1 m$,
$\overline{e d_1}^2 = \overline{e m}^2 + \overline{m d_1}^2 = (\overline{e i_1} + \overline{i_1 m})^2 + \overline{m d_1}^2$; or, because in the right triangle $m d_1 i_1$ we have, $\overline{i_1 m} = h \cos a_1$, and $\overline{m d_1} = h \sin a_1$,

$$\begin{aligned} \overline{e d_1}^2 &= (k + h \cos a_1)^2 + h^2 \sin^2 a_1 \\ &= k^2 + 2 k h \cos a_1 + h^2 (\sin^2 a_1 + \cos^2 a_1) \\ &= k^2 + 2 k h \cos a_1 + h^2, \qquad (1) \end{aligned}$$

because the sum of the squares of the sine and cosine of any angle is always equal to 1

The next thing to determine is the amount of rolling of the wheel in terms of the constants and the angle x. If this angle is expressed in degrees, the length of the arc subtended by it at unit's distance from the center is found as follows: Since the length of half a circumference, to radius 1, is π, and this is the arc subtended by an angle of 180°, the arc subtended by an angle of 1° is $\frac{\pi}{180}$, and the arc subtended by an arc of $x°$ is $\frac{\pi x}{180}$. Let $\frac{\pi x}{180}$ be denoted by x'. The length of the arc subtended by the same angle at any distance d is evidently $d x'$.

Produce $i_1 w_1$ to meet $i_1' w_1'$ produced at n_1. The two triangles $e i_1 d_1$ and $e i_1' d_1'$, having all their sides equal, are equal; therefore, angle $d_1 i_1 e = d_1' i_1' e$, and $e i_1' w_1' = e i_1 w_1 = a_1$. In the triangles $e s_1 i_1$ and $n_1 s_1 i_1'$, the vertical angles at s_1 are equal, and $a_1 = a_1$; therefore, $s_1 n_1 i_1' = s_1 e i_1 = x$. Draw $i_1 w_1''$ parallel to $i_1' n_1$; then,

$$w_1 i_1 w_1'' = s_1 n_1 i_1' = x.$$

Now, the motion of the wheel may be decomposed into three different motions: *First*, a motion of rotation about i_1, by which the wheel is brought to the position w_1'', along the arc $w_1 w_1''$. As the direction of this motion is at every point perpendicular to the axis of the wheel, all the motion will be rolling,

and its amount will be the length of the arc $\overline{w_1 w_1''} = \overline{i_1 w_1''} \times x' = l x'$. It will be readily seen that this rolling is counter-clockwise (always looking from w_1 towards d_1), or negative. *Second*, a motion of translation along $w_1'' w_1'''$ to a point w_1''' directly opposite w_1'. As this motion is constantly in the direction of the axis of the wheel, it will produce no rolling, and will not be recorded by the instrument. *Third*, a motion perpendicular to $i_1 w_1'''$, from the position w_1''' last occupied by the wheel to w_1'. As here, again, the motion is constantly perpendicular to the axis of the wheel, all the motion will be rolling, and will be registered by the instrument; its amount will be equal to the distance between the parallel lines $i_1 w_1'''$ and $i_1' w_1'$, which is equal to $i_1 p_1$, perpendicular to both lines. The rolling is evidently clockwise, or positive. The arc $i_1 i_1' = \overline{e i_1} \times x' = k x'$ being "infinitely small," it may be considered as a straight line perpendicular to $e i_1$, and we may write, $i_1 i_1' p_1 = 90° - a_1$, and $\sin i_1 i_1' p_1 = \cos a_1$. In the right triangle $i_1 i_1' p_1$ we have,

$$i_1 p_1 = \overline{i_1 i_1'} \sin i_1 i_1' p_1 = k x' \cos a_1.$$

As the rolling from w_1 to w_1'' is in the opposite direction to that from w_1''' to w_1', the total amount of rolling registered by the wheel will be the difference between the two. If we call the rolling W_1, we have, finally,

$$W_1 = k x' \cos a_1 - l x'. \qquad (2)$$

We now move the pointer along $d_1' d_2'$ to d_2'. During this motion, the wheel will roll by a certain amount, and the angle a_1 will change to a different angle, which we shall call a_2 (not shown). It is, however, evident that, if we move the pointer back from d_2' to d_1', along $d_2' d_1'$, the wheel will retrace its former path, rolling in a direction opposite to its former direction; and this fact makes it unnecessary to consider the rolling of the wheel due to the motion $d_1' d_2'$ of the pointer, as we shall presently see. Reasoning as before, the rolling W_2 due to the motion of the pointer from d_2' to d_2 is

$$W_2 = l x' - k x' \cos a_2. \qquad (3)$$

When the pointer is at d_2, the relative position of all the parts is the same as when it was at d_2', since the instrument revolves as a rigid whole; therefore, the motion of the pointer from d_2 to d_1 will produce the same rolling of the wheel as would be produced by the motion of the pointer from d_2' to d_1', the effect being that the rollings due to the pointer motions $d_1' d_2'$ and $d_2 d_1$ will balance each other, and will therefore not affect the record of the wheel. The final record W of the wheel is, then, the sum of (2) and (3), or

$$W = W_1 + W_2 = k x'(\cos a_2 - \cos a_1). \qquad (4)$$

Now, the area A of $d_1 d_1' d_2' d_2$ is the difference between the sectors $d_1 e d_1'$ and $d_2 e d_2'$. The area of a sector, it will be remembered, is, like the area of a triangle, equal to one-half the product of its base by its altitude, its base being its curved boundary, and its altitude the radius of the circle. Therefore,

$$\text{sector } d_1 e d_1' = \tfrac{1}{2} \overline{e d_1} \times \overline{d_1 d_1'},$$
$$\text{sector } d_2 e d_2' = \tfrac{1}{2} \overline{e d_2} \times \overline{d_2 d_2'}.$$

But $\overline{d_1 d_1'} = \overline{e d_1} \times x'$,

and $d_2 d_2' = \overline{e d_2} \times x'$;

therefore,

$$\text{sector } d_1 e d_1' = \tfrac{1}{2} x' \times \overline{e d_1}^2,$$
$$\text{sector } d_2 e d_2' = \tfrac{1}{2} x' \times \overline{e d_2}^2,$$

and $A = \tfrac{1}{2} x' (\overline{e d_1}^2 - \overline{e d_2}^2)$.

But [formula (1)]

$$\overline{e d_1}^2 = k^2 + 2 k h \cos a_1 + h^2$$
$$\overline{e d_2}^2 = k^2 + 2 k h \cos a_2 + h^2$$
$$\overline{e d_1}^2 - \overline{e d_2}^2 = 2 k h (\cos a_2 - \cos a_1);$$

therefore,

$$A = \tfrac{1}{2} x' \times 2 k h (\cos a_2 - \cos a_1)$$
$$= h \times k x' (\cos a_2 - \cos a_1),$$

or [formula (4)]

$$A = h \times W. \qquad (5)$$

This shows that *the area circumscribed by the pointer is measured by the rolling of the wheel multiplied by the length of the circumscribing arm* $i_1 d_1$.

We have seen that, while the pointer is moved along $d_1 d_1'$, the *positive* rolling of the wheel is $k x' \cos a_1 - l x' = (k \cos a_1 - l) x'$. It may, however, happen that the angle a_1 is so large as to make $k \cos a_1$ less than l, in which case the preceding expression becomes negative, showing that the resultant rolling is counter-clockwise. But in this case formula (5) applies equally well. In the lower part of Fig. 2, we have a case in which not only $k \cos a_3$ is less than l, but, the angle a_3 being obtuse, $k \cos a_3$ itself is negative. The area to be measured is $d_3 d_3' d_4' d_4$. When the pointer moves from d_3 to d_3', the wheel moves from w_3 to w_3'. As before, this motion is equivalent to a turning motion of $i_3 w_3$ about i_3, to bring it to the position $i_3 w_3''$, parallel to $i_3' w_3'$; a motion of translation along $i_3 w_3''$, to bring the wheel to w_3''', opposite w_3'; and a motion of translation from w_3''' to w_3', along the line $w_3''' w_3'$. The second motion does not affect the record of the wheel. The first motion is negative, and equal to

$$\overline{w_3 w_3''} = \overline{i_3 w_3} \times x' = l x';$$

for the angle $w_3 i_3 w_3'' = w_3 n_3 w_3'$, and the latter angle is equal to $s_3 e i_3' = x$, as will be

at once seen by comparing the triangles $n_3 s_3 i_3$ and $e s_3 i_3'$. The third motion is also negative, and its value is

$$w_3''' \overline{w_3'} = \overline{i_3 p_3} = \overline{i_3 i_3'} \sin i_3 i_3' p_3 = k x' \cos e i_3' s_3.$$

Therefore, the total rolling is

$$W_3 = -l x' - k x' \cos e i_3' s_3;$$

or, because the cosine of an angle is equal to *minus* the cosine of its supplement,

$$W_3 = -l x' - k x' \times (-\cos a_3)$$
$$= (k \cos a_3 - l) x'.$$

Similarly, the rolling from d_4' to d_4 will be

$$W_4 = (l - k \cos a_4) x',$$

and the total rolling,

$$W = W_3 + W_4 = k x' (\cos a_3 - \cos a_4),$$

which is of the same form as formula (4).

It is to be noticed, that, whatever the values of the angles corresponding to the upper and lower arcs (as a_1 and a_2, a_3 and a_4), the total rolling of the wheel will always be positive, if the pointer is moved clockwise around the figure (as $d_1\,d_1'\,d_2'\,d_2$ and $d_3\,d_3'\,d_4'\,d_4$). Taking formula (4) to represent the general case, and remembering that a_2 is always greater than a_1, and that the cosine of an angle decreases as the angle increases, it follows that $\cos a_1$ is always greater than $\cos a_2$. It is easy to see that this is true, whatever the values of a_1 and a_2 may be, between 0° and 180°, provided a_1 is always greater than a_2.

Referring again to Fig. 2, we may, by following the method used for $d_1\,d_1'\,d_2'\,d_2$, find the area $d_3\,d_3'\,d_4'\,d_4$ to be

$$h \times k x' (\cos a_3 - \cos a_4) = h \times W,$$

as in formula (5).

(To be Continued.)

DUTY OF STEAM PUMPS.

G. Herbert Follows.

MEANING OF THE WORD DUTY—HOW THE WORK DONE BY A STEAM PUMP IS MEASURED. COMPARISON OF THREE DIFFERENT WAYS OF COMPUTING DUTY.

WHEN a pump and the steam engine which drives it are permanently coupled together, in such a manner as to form, practically, one machine, the combination is called a *steam pump*. There are, broadly speaking, two types of steam pumps. The combination in which the pump is driven by means of a crank is called a *steam crank pump;* while that in which the plunger of the pump and the piston of the steam engine are attached to the same piston rod belongs to the type known as *direct acting.* Very large steam pumps are generally spoken of as *pumping engines.*

In the accompanying illustration, which is a conventional representation of a modern pumping plant, *B* is the boiler house with nest of three boilers and steam piping *s*; *P* is the pump house proper, containing a direct-acting steam pump, or pumping engine, in which *a* is the high-pressure cylinder, *b* the low-pressure cylinder, *e* the exhaust pipe, and *p* the pump; *c* is the suction main which takes water from the supply reservoir *w*, and *d* is the discharge, or force, main, which runs straight back and delivers into the stand pipe, or water tower, *f*, the height of which is such that the head of water obtained produces the necessary pressure in the town or city which it supplies.

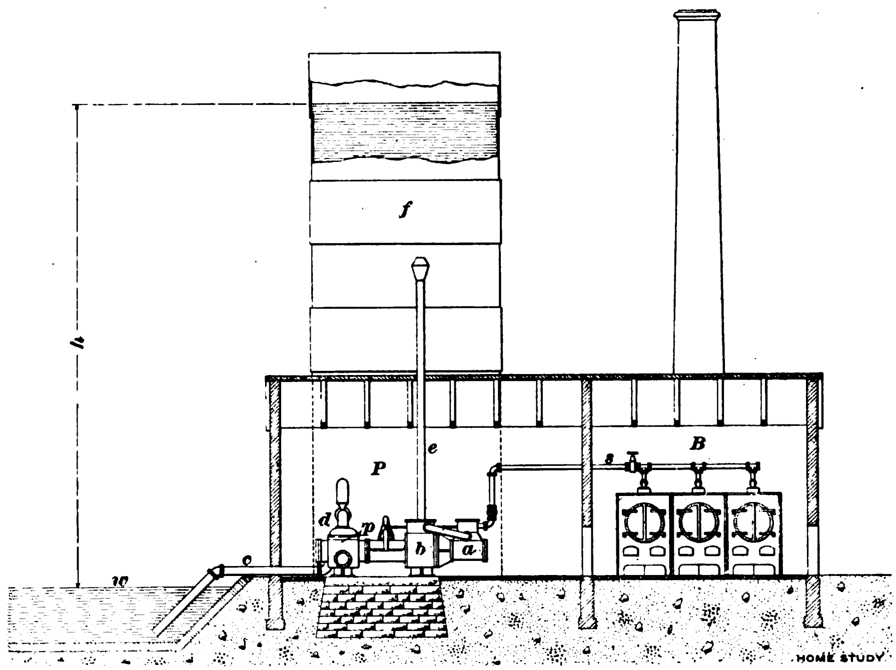
When comparing the performances of different kinds or sizes of steam pumps, it is not enough to know merely how much work each pump will do in a given time; a moment's reflection will make this point clear, for, though a large pump may lift *three* times as much water per hour as a smaller one, it may take *five* times as much steam to do it; in which case it would be more economical to use three of the small pumps. From this we conclude that it is necessary to know, in addition to the amount of work a pump will do, what it *costs* to do it. Now, other things being equal, the cost depends upon the amount of coal consumed in driving the pump, from which it is obvious that *the amount of work done, per pound of coal consumed*, provides a basis upon which pumps of any size or capacity can be roughly compared.

About the year 1780, when Boulton & Watt first introduced their pumping engines in the English mines, they did so with the understanding that their compensation should be derived from a share in the saving of fuel, and they fixed upon a bushel of coal,

about 94 pounds, as the unit measure of fuel, afterwards changing this unit to one cwt., or 112 pounds.

This led, in course of time, to the custom of gauging the merits of a pump by measuring the amount of work it would do at the expenditure of a given quantity of fuel, until, finally, by common consent in America and most European countries, the unit measure of fuel, by which to compare all steam pumps, was fixed at 100 pounds; and the amount (expressed in foot-pounds) of work done by a steam pump for every 100 pounds of coal consumed in running it was called the *duty* of the pump. To make the meaning

Many steam-pump makers, to guard against trouble in connection with the design or efficiency of the boiler, changed the basis of 100 pounds of coal to 1,000 pounds of dry steam supplied to the engine. Finally, in order to avoid variations of duty, occasioned by any difference in quality of coal or design of boiler, it was suggested by the American Society of Mechanical Engineers, in 1891, that the basis be changed to 1,000,000 heat units. One million was chosen because it is approximately the number of heat units which 100 pounds of good coal will yield to the water in a well designed boiler, so that duties determined by the two methods could be



of this quite clear, let us take, as an example, a pump which raises 7,500 pounds of water to a height of 100 feet for the consumption of 100 pounds of coal in the furnace; the duty of this pump is $7{,}500 \times 100 = 750{,}000$.

It is obvious, however, that, when estimating the duty in this way, different qualities, or kinds of fuel, will produce misleading variations in the estimated duties of different pumps; also, that much will depend upon the design of the boiler and the furnace, the area of grate surface, the nature and velocity of draft, the percentage of moisture in the steam supplied to the engine, as well as upon the connections between the boiler and the engine.

compared without leading to any serious misapprehension. This basis is now very extensively used in this country.

In conducting a *duty trial*, whatever the basis may be, it is necessary to know how much water has been raised and delivered by the pump. It is not often convenient to measure the actual quantity delivered, so that some other method has to be resorted to. Usually the measurement is made by what is called the plunger-displacement system, that is, by a calculation of the volume of water displaced, or discharged, by the pump plunger during the trial.

Now, if there were no *slip*, that is, leakage of water around the pump plunger, the

distance swept through by the plunger, multiplied by its area, would equal the volume of water discharged. There is always leakage, however, and the exact amount must be ascertained. One way of doing this is first to secure the plunger against any movement, and then admit water on one side of it at full working pressure, carefully measuring the volume of water which leaks through in a given time. From this, the volume of leakage, during any duty trial, can readily be computed. Then, the total quantity of water delivered by the pump will be equal to the area of the plunger, multiplied by the length of stroke, multiplied by the total number of strokes during the trial, minus the total leakage; or, putting this in the form of an equation

$$V = (a \times s \times n) - v.$$

where

a = area of pump plunger in square feet;
s = length of stroke in feet;
n = total number of strokes during the duty trial;
V = total volume of water delivered, in cubic feet;
v = total leakage in cubic feet.

The *amount of work done*, in foot-pounds, is equal to the weight of water delivered, in pounds, multiplied by the total height raised, in feet, i. e., the vertical height from the level of water at the source of supply to the level of water in the stand pipe f; this height is represented by h in our illustration.

The total weight of water is equal to the volume V, multiplied by the weight of 1 cubic foot of water, which is about 62.5 pounds.

Let W = the total weight of water raised;
h = total vertical height raised.

Then, $W \times h$ = work done, in foot-pounds.

Now, what mostly concerns those who are responsible for the economic running of a pumping plant is the duty of the whole system, that is, the relation between the amount of work done and the quantity of coal consumed in doing it, or, expressing this in the form of duty, the number of foot-pounds of work for every hundred pounds of coal consumed; so that, if C equals the *total* number of pounds of coal consumed,

$$\text{Duty} = \frac{W \times h}{C} \times 100.$$

This is the old expression of duty, and is still sometimes used when the question of coal consumption alone is considered. It tells us nothing, however, about the details of the plant. We learn that it takes so many pounds of coal to raise so many pounds of water, but that is all. We ascertain nothing as to the efficiency of the boiler, or of the duty of the pump itself, or of the suitability of the suction main for supplying water to the pump, or the force main for delivering it to the stand pipe, or reservoir.

An attempt was made to divide responsibility—separating the performance of the pumping engine from that of the boiler which supplied the steam—when the suggestion was made that 1,000 pounds of dry steam, supplied to the pump, be substituted for the basis of 100 pounds of coal. This was done on the assumption that 1 pound of coal was capable of converting into dry steam 10 pounds of water from and at 212° F. On this basis the expression for duty became

$$\text{Duty} = \frac{W \times h}{S} \times 1{,}000,$$

where S equals the total number of pounds of dry steam supplied to the pumping engine. This basis, however, did not obtain much favor; condensation in the steam pipes made the weighing of the dry steam, actually supplied to the engine, a matter of no little difficulty, and the quantity of water converted into steam by 1 pound of coal depended not only upon the character of the fuel but upon the design of the boiler, so that this basis was soon abandoned.

We come now to the heat-unit basis. A heat unit is the quantity of heat which is capable of raising the temperature of 1 pound of water 1° F., under atmospheric pressure; this is called the *British thermal unit*. (See HOME STUDY MAGAZINE, February, 1897, article entitled, "Boiler Trials.") Now, 1 pound of good commercial furnace coal, whether anthracite or bituminous, will yield about 12,500 heat units; 2,500 of these, however, will, in the average boiler, escape up the chimney, leaving only 10,000 useful heat units; 100 pounds of coal will, then, impart to the water in the boiler, approximately, $10{,}000 \times 100 = 1{,}000{,}000$ heat units, so that—remembering that it takes 975.7 heat units to convert 1 pound of water, at 215° F., into steam—for an evaporation of $\frac{10{,}000}{965.7} = 10.355$ pounds of water per pound of fuel, the new heat-unit basis is the exact equivalent of the old basis of 100 pounds of coal, but has the advantage of being absolutely independent of either the quality of coal used or the efficiency of the boiler.

For these reasons, it was strongly recommended by the American Society of Mechanical Engineers that the old basis of 100

pounds of coal, as well as that of 1,000 pounds of steam, be abolished, and universally replaced by the basis of 1,000,000 heat units, the expression of duty to be,

$$\text{Duty} = \frac{\text{foot-pounds of work done}}{\text{total number of heat units consumed}} \times 1{,}000{,}000.$$

It is recommended that, in measuring the quantity of water discharged into the force main, the plunger-displacement system be used, but that, whenever convenient, additional measurement be made by either weir, nozzle, or venturi tube.

In determining the quantity of work done, the work expended in overcoming the friction of both force and suction mains should be neglected, but the work of overcoming the friction of the water in the passages of valves on the pumps should be included in that on which the duty is computed; this means that the duty of the pumping engine shall not be dependent upon anything foreign to itself, but that the builder of the engine shall only be responsible for the work done from the moment the water enters the pump to the moment it leaves it. The purchaser is thus left to guard his own interests by seeing that the water mains are of sufficient capacity to reduce friction to a minimum.

The amount of heat supplied to the engine must include not only that supplied to the engine cylinders, but also that supplied to all apparatus necessary to the operation of the engine. The number of foot-pounds of work done by the pump should be estimated in the following manner: A pressure gauge should be placed on the force main, close to the pump; and a vacuum gauge on the suction main, also close to the pump.

Let A = area, in square inches, of the pump plunger, allowance being made for the area of the plunger rod.

P = pressure, in pounds per square inch, indicated by the gauge on the force main.

p = pressure, in pounds per square inch, indicated by the vacuum gauge on the suction main.

s = pressure, in pounds per square inch, corresponding to the vertical distance between the two gauges; this is equal to the distance in inches multiplied by the weight of a cubic inch of water, which is .0361 pound.

L = average length of stroke of plunger, in feet.

N = total number of single strokes of plunger made during the trial.

Then,

$$\text{Foot-pounds of work done} = A(P + p + s) \times L \times N.$$

If the suction main is under a head, the vacuum gauge should be replaced by a pressure gauge, and then,

$$\text{Foot-pounds of work done} = A(P - p + s) \times L \times N.$$

From this we obtain the final and full expression for the duty of a pumping engine, which is

$$\text{Duty} = \frac{A(P \pm p + s) \times L \times N}{H} \times 1{,}000{,}000,$$

where H = total number of heat units supplied.

It is strongly recommended that the duration of a duty trial be such that the same expert may, without undue physical exertion, have the test under his continuous supervision from beginning to end, and this is possible where the time is not more than ten hours.

STRESSES IN A BICYCLE FRAME.

Benj. F. La Rue.

ASSUMED CONDITIONS OF LOADING THAT PRODUCE MAXIMUM STRESSES—DETERMINATION OF THE STRESSES BY MEANS OF STRESS DIAGRAMS.

THE bicycle has attained, in a comparatively short time, a popularity that is truly remarkable. It is now one of the most familiar objects to be seen on the streets of our cities, and has undoubtedly come to stay. As a means of pleasure and for convenience of transportation, under certain conditions, it is without a rival, being rapid, pleasant, healthful, and exhilarating.

It is generally understood that, in order to reduce the weight of a bicycle so that it may be easily propelled, all its parts are made as light as is considered compatible with the essential condition of safety. By reason of this fact, and of the wide-spread popularity of the bicycle, it will be interesting to investigate statically the stresses in the members of a bicycle frame, produced by the applica-

tion of certain assumed loads, no such investigation having, so far as we know, been published before.

It should be understood that, owing to the varying conditions involved—many of which are to some extent indeterminate—any such investigation can be only approximate, though by means of certain reasonable assumptions we may be able to obtain results that closely approximate the actual stresses. The assumptions of loading here made comprehend by no means the entire range of possible conditions producing stress, but include merely a few of the conditions most common.

The frame chosen is that of a standard Columbia bicycle, model of 1897, gentleman's wheel. A graphical analysis will be given, determining the stresses in the members of this frame due to the loads and conditions of loading assumed. An outline diagram, giving the dimensions of the frame, is shown in Fig. 1. The dimensions are from center to center of connections. As, however, the centers are not all well defined points, these dimensions should be regarded as merely approximate. For instance, the joint d_0 is not a single simple joint at which the members c_0d_0, d_0e_0, and d_0f_0 connect concentrically, although it is so shown in the figure and considered in the analysis; it partakes rather of the nature of two joints close to each other and rigidly connected. In the analysis, moreover, it is assumed that the members connecting at the joints d_0, e_0, and f_0 are free to turn upon those joints, no bending moment being produced—the members d_0e_0, e_0f_0, and d_0f_0 being supposed to thus sustain direct longitudinal stresses only. As the connections are rigid, this assumption is not strictly correct. It is permissible, however, and, with certain other consistent assumptions, will enable us to construct the complete stress diagram for the frame.

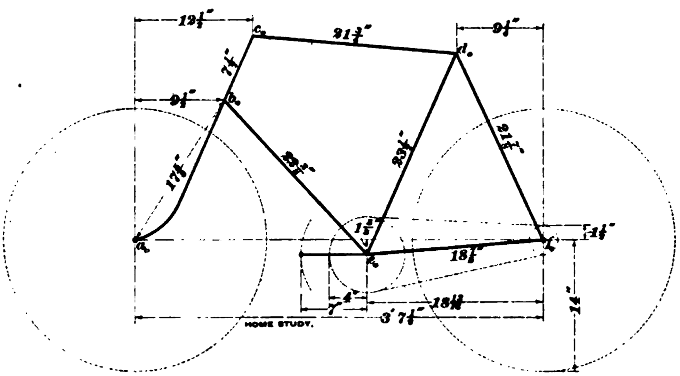


FIG. 1.

The stress diagrams, as constructed for the different conditions of loading assumed, are exceedingly interesting. Rather unusual expedients have been resorted to in their construction, by which complete analyses have been obtained; so that each stress diagram shows, for the condition of loading assumed, not only the direct longitudinal stresses in the several members, but also the forces producing bending moments. In the investigation of the stresses, the dead load, that is, the weight of the frame itself, and of the saddle, handle bars, and gearing, is wholly neglected. The stresses due to these may be determined by substantially the same method as that explained, by considering the dead load to be concentrated, in the proper proportions, at the various joints.

First Condition: Load Entirely on Saddle.—It will first be assumed that the weight of the rider (200 pounds) is supported wholly upon the joint d_0—which is the approximate position of the saddle—9¼ inches horizontally ahead of the center of the rear wheel. Through the medium of the frame, the load is transferred to and supported upon the centers of the two wheels, which are 3 ft. 7½ in. = 43½ inches apart. The reactions upon the frame are therefore considered as acting at these points. Designating the reaction of the forward wheel by R_1 and that of the rear wheel by R_2 we have, by taking moments about R_2,

$$R_1 \times 43.5 - 200 \times 9.25 = 0,$$

from which

$$R_1 = \frac{200 \times 9.25}{43.5} = 42.5 \text{ pounds};$$

and, by taking moments about R_1, we have

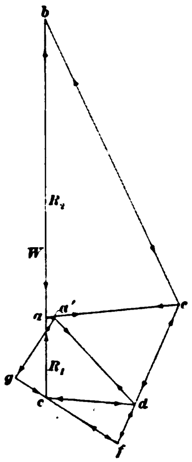
$$-R_2 \times 43.5 + 200 \times (43.5 - 9.25) = 0,$$

from which

$$R_2 = \frac{200 \times 34.25}{43.5} = 157.5 \text{ pounds}.$$

An outline diagram of the frame, drawn to scale, and the stress diagram determining the stresses in its various members with this condition of load, are shown in Fig. 2. For convenience of reference, the members of the

frame and corresponding stresses are designated by a system of lettering known as *Bow's notation*. The members of the frame and lines of forces acting upon it, are designated by letters written in the spaces, while the lines of the stress diagram are designated by letters at the angles. Each space not crossed by a member of the frame or other line of force is designated by the same letter throughout the diagrams. A line of the stress diagram, designated by a letter at each end, represents to scale the magnitude of the stress in that member of the frame which is situated between the corresponding letters, or the force whose line of action lies between them. Thus, the line $a e$ represents the stress in the member $A E$; the line $b c$ represents the force $B C$, that is, the load W.



The stress diagram is begun by considering the forces that act upon the joint f_0. The reaction R_2 is known, and, by laying off upward $a b$ to any convenient scale equal to $R_2 = 157.5$ pounds, the stresses $b e = 166.5$ pounds, and $e a = 70.5$ pounds, in the members $B E$ and $E A$, are determined by completing the force polygon $a b e a$ for this joint. For the joint d_0, the stress in $B E$ and the load $W = 200$ pounds, are known, and the stresses $c d = 47$ pounds, and $d e = 57.5$ pounds, in the members $C D$ and $D E$ are determined by completing the force polygon $e b c d e$. So far, the stress diagram is perfectly regular. In considering the forces that act upon the joint e_0, however, we have $a e$ as the stress in $A E$, and $e d$ as the stress in $E D$, but we find that a line drawn from d parallel to the member $D A$ will not close upon a, showing that some other force acts upon this joint. The condition of equilibrium will be fulfilled by a force $a' a = 4.5$ pounds, acting in the direction $e_0 a_0$, which may be due to bending moment in the member $D A'$; such a force will close the polygon $a e d a' a$ giving $a a'$ as the stress in $D A'$.

It is evident that the reaction R_1 applied at a_0 produces both compression and a bending moment in the fork $a_0 b_0$, or $G A'$, and in the member $b_0 c_0$, or $D F$. As a bending moment cannot be represented by the stress diagram, special expedients must be resorted to for determining the stresses in the remaining members of the frame. The forces acting in these members will be resolved into components representing direct longitudinal stress in the members, and normal components

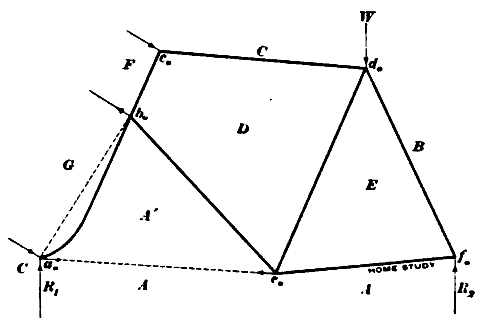


FIG. 2.

producing bending moment, so that the effect of both can be easily determined.

The longitudinal stresses produced in the members $C D$ and $D A'$ by a force applied at a_0 will not be affected by the *form* of the intervening members through which the effect of the force is transmitted. In order, therefore, to obtain an analysis of the stresses, we may assume the member $a_0 b_0 c_0$, which is subjected to bending stress, to be removed, the members $d_0 c_0$ and $e_0 b_0$ produced to an intersection at m_0, and the imaginary members $a_0 m_0$, or $C A'$, and $a_0 e_0$, or $A' A$, introduced, as shown in Fig. 3. We now have a frame in which all the members may be free to turn upon the joints at which they connect, and subjected to direct longitudinal stresses only, so that we can easily complete the stress diagram. For the joint a_0, the force polygon $c a a' c$ may be drawn. It will be noticed that the stress $a a'$, obtained for the imaginary member $A A'$ corresponds exactly to the force $a' a$ required to close the polygon for the joint e_0. We also find that the polygon $c a' d c$ for the joint m_0 gives the stresses $a' d$ and $d c$ for the members $A' D$ and $D C$, as previously obtained by the polygons for joints d_0 and e_0. These stresses may be further verified by moments. Taking moments about b_0 (see Fig. 1), we have

$$\text{Stress in } CD = \frac{42.5 \times 9.5 - 4.5 \times 15.375}{7.125} = 47 \text{ lb., nearly.}$$

Similarly, taking moments about c_0, we get

$$\text{Stress in } DA' = \frac{42.5 \times 12.5 - 4.5 \times 22.5}{6.875} = 62.5 \text{ lb.,}$$

the same as given by the stress diagram.

It still remains to determine the stresses in the fork $a_0 b_0$ and the member $b_0 c_0$. These members will now be considered as restored, as in Fig. 2, all the imaginary portion of the frame to the left of them being removed. So far as its effect upon the joints a_0, b_0, and c_0 is concerned, the bent fork $a_0 b_0$ acts exactly as would a straight member in the position of the dotted line $a_0 b_0$, which straight member will now be referred to as $G A'$.

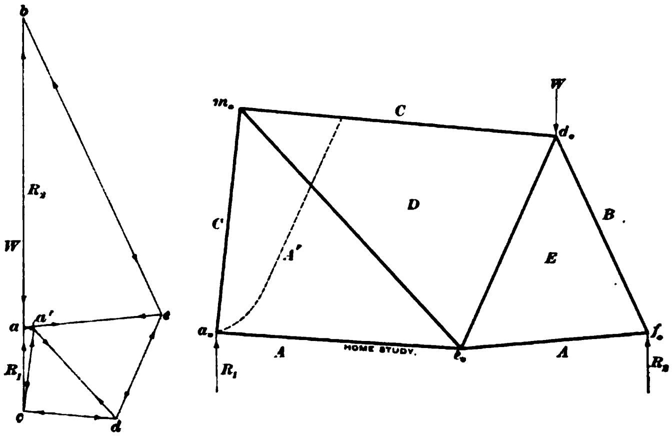


FIG. 3.

The reaction R_1 upon the joint a_0 is resisted by the direct thrust of the member $G A'$ and by the forces $A A'$ and $G C$, representing the effect of the resistance of that member to bending, that is, representing forces exactly equal and opposite to the bending forces acting upon that member.

These resisting forces, or forces opposed to the bending forces, are pressures exerted upon the joint a_0 by the member $G A'$, by means of its capacity to resist bending; they are, through the medium of the member, finally balanced by similar forces acting at other points. The force $A A'$ of the bending resistance, acting upon the joint a_0, is exactly balanced by a corresponding force acting upon the joint e_0; it produces a small amount of longitudinal stress in the member $A' G$, but otherwise causes no pressure upon the joint b_0. The force $G C$ of the bending resistance is normal to the member $A' G$ and has no effect upon the longitudinal stress in that member. It is balanced by the forces $G F$ and $F C$ acting upon the joints b_0 and c_0, respectively; these forces are also normal to the member $A' G$, and are due wholly to the ability of that member to withstand bending.

Having thus considered the nature of the various forces, we can draw the force polygon $c a a' g c$ for the forces acting upon the joint a_0, determining the longitudinal stress in $A' G = a' g = 38$ pounds, and the force $G C$, due to the bending resistance $= g c = 19$ pounds. For the forces acting upon the joint b_0, the force polygon $g a' d f g$ is drawn, determining the amount of longitudinal stress in $D F = d f = 22.5$ pounds, and the force $F G = f g = 64.2$ pounds. The polygon for joint c_0 is $f d c f$, giving the force $C F = c f = 45.2$ pounds. The last two results can be easily verified by moments. Taking moments about the joint c_0, we have

$$\text{Force } F G = \frac{19 \times 25}{7.4} =$$

64.2 pounds, nearly. Similarly, by taking moments about the joint b_0,

$$\text{Force } C F = \frac{19 \times 17.6}{7.4}$$

$= 45.2$ pounds, the same as given by the stress diagram.

The maximum bending moments in the members $A' D$, $D F$, and $G A'$ occur at the joint b_0. The maximum bending moment in $A' D$ is equal to the force $A A'$ multiplied by its lever arm or perpendicular distance from $b_0 = 4.5 \times 15.4 = 69.3$ inch pounds; that in $D F$ is equal to the force $C F$ multiplied by its lever arm, or $45.2 \times 7.4 = 334.5$ inch-pounds, nearly. The maximum bending moment in $G A'$ resists both these bending moments, and is therefore equal to their sum, or $69.3 + 334.5 = 403.8$ inch-pounds. This may also be determined by taking the moment of the vertical reaction of R_1, or of the forces $G C$ and $A A$, about the joint b_0.

The magnitudes of all stresses and forces acting in and upon the frame, due to an assumed load of 200 pounds supported at the joint d_0, have now been determined, being given by the stress diagram of Fig. 2, which is in all respects complete. The magnitude of the stress in any member of the frame will be given by the length of that line of the stress diagram included between

the corresponding letters, measured to the same scale as that to which the loads and reactions were laid off. Each line of the stress diagram on which the two arrowheads point toward each other, or away from the ends of the line, represents tensile stress; and each line on which the arrowheads point away from each other, or toward the ends of the line, represents compressive stress. The process of constructing the diagram has been explained in detail, and, though the explanation has necessarily been somewhat lengthy, it is hoped that it has proved of sufficient interest not to have been tedious. The remaining stress diagrams for the other conditions of loading assumed are so similar to the stress diagram of Fig. 2 that no extended explanation will be required.

(To be Continued.)

LIGHTNING PROTECTION.

N. H. Brown.

Electric Current From a Thunder Cloud is Similar to That From a Dynamo—Lightning Arresters and Their Construction.

IT HAS frequently been said that lightning does not follow physical laws, and that, therefore, nothing can be wisely done to guard against its destructive work. This is a mistake. It should rather be said that we do not *understand* the law that governs the lightning and causes its apparently erratic behavior. So that, before attempting to lay down rules for constructing devices for protection from lightning, we should study the action of electric currents. It has been shown that the electric current from a thunder-cloud is exactly the same, except in intensity and form of discharge, as that from a dynamo or battery.

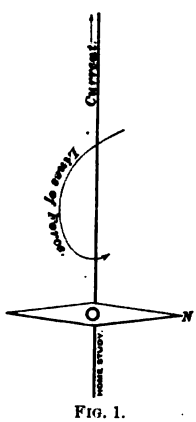


Fig. 1.

Now, if a current of electricity is sent through a wire, a magnetic field is set up around that wire, such as to cause a compass needle to tend to set itself at right angles to the wire—as in Fig. 1. If we coil the wire, it becomes a solenoid, and when the current flows through the solenoid it acts as if it were a magnet.

As long as the current of electricity flows steadily—without either increase or decrease—no part of the force required to cause the current to flow is used to maintain the magnetism, or lines of force through the coil, and the current obeys Ohm's law. But as soon as any change of current is attempted, the coil opposes that change. This tendency to oppose current changes is called *self-induction.* All circuits have some self-induction, but coils have very much more than straight wires.

The force opposing the change of current depends not only upon the wire, but upon the rate at which the change is made. To make this perfectly clear, let us take an example. If we have one ampere flowing through a wire, and attempt to change it to two amperes in one second of time, a certain opposition caused by induction will have to be overcome. If, however, we attempt to make the same change of current in *one-tenth* of a second, the induction will be ten times as great, or if in one-thousandth of a second, one thousand times as great, and so on.

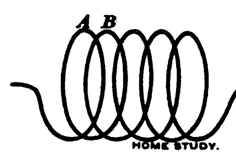


Fig. 2.

For all ordinary currents, the effect produced by the mere forming of the wire into a coil of a few turns is so slight that the difference may be ignored. With lightning it is different. A "flash" of lightning is never produced by a single discharge; the discharge is oscillatory, flowing across and back many thousands of times. These oscillations take place so rapidly that several hundred thousand can be completed in a single second. Now, while a little self-induction has but little influence on currents that change comparatively slow, it has a great effect on those that change very rapidly; for, although the current itself may be small, the rate at which it changes will be high if the changes are very rapid. This

effect is so great, in fact, that lightning frequently jumps across from wire to wire, as from A to B in Fig. 2, rather than go around the coil.

If the wires from and to which the current jumps are reasonably large, there is seldom much damage done by the lightning itself. Sometimes, however, the spark, as it jumps, causes a temporary low resistance, and the dynamo attached to the circuit furnishes the current to flow through this low resistance, forming an arc that destroys everything in its vicinity—armature of dynamo included. Thus, dynamos and motors are frequently burned out as the result of a stroke of lightning, although the stroke itself may not have been great enough to burn out a No. 30 wire.

FIG. 3.

There are, then, distinct classes of machines needing lightning protection in two quite different ways.

The first class comprises those instruments that have small wire parts with low applied potential, such as telephones, electric bells, annunciators, fire alarms, etc. These can be readily and fairly well protected by a very inexpensive device. As all machines of this kind require the same treatment, one illustration, the telephone, will suffice. Telephones should have their line wires brought in with as little coiling as possible to a lightning arrester, as shown in Fig. 3. A good-sized wire or small cable should lead from B to the nearest water pipe or ground. This wire *must not be coiled* at any point. Wires leading from A and C to the instrument should be as large as No. 18, and should be freely coiled as shown. In this way, the lightning is prevented from reaching the instrument, where it would do harm, and is at the same time allowed to freely pass to the ground, for the coiled wire presents to the current a much greater hindrance than the spark gap. The spark will pass from A to B and from C to B and thus to ground, all being done so quickly that, if a person is using the telephone when the discharge takes place he will hear only a slight snap, which need not in the least interfere with his use of the line.

The second class of machines requiring lightning protection comprises those that have generated in them or applied to them a high electromotive force, and includes such forms as motors, dynamos, transformers, etc. These are best protected by some of the patented devices that blow out the arc at the lightning arrester, if one is formed. It is well in these cases to have the wires coiled somewhere between the lightning arrester and the machine, so that no part of the lightning shall reach the machine; for, no matter how good the arrester may be, it is of no avail when once a spark jumps from one coil to another in the armature of the machine, and an arc is formed.

If a high-priced lightning arrester is out of the question, the same kind that was used on the instruments of low potential can be advantageously used if a fuse is introduced on each side of each terminal, as in Fig. 4. Except in the case of grounded circuits, these fuses will very rarely blow, and, if one of them does, it is much easier to replace a fuse than an armature. When there are no motors on the circuit, the fuses on the side opposite the machine can be omitted, for there will be no outside source of electromotive force which could cause a destructive current to flow.

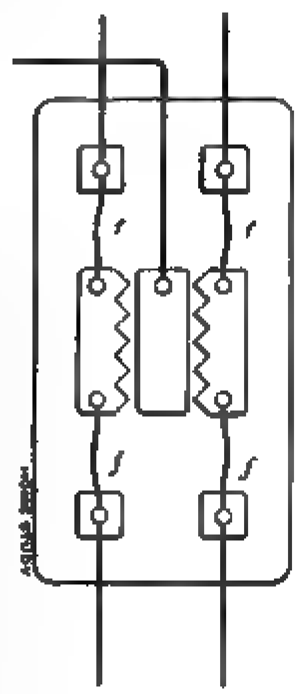


FIG. 4.

Electric lines are seldom struck by lightning. Usually a cloud bearing a heavy electric charge moves towards the line, and the wire acquires an induced charge from the ground by leakage. This may go on for several minutes. Then, when the line has a heavy charge, the cloud may pass quietly by and away to a distance, in which case the line charge will disappear as quietly as it came. But, if the cloud discharges to the earth or to another cloud while it is still near the line, the wire will have a heavy charge which is no longer bound to it This is what the lightning arrester should care for. Probably ninety-nine discharges out of every hundred are of this sort. So, as a rule, a line will discharge only what it can

hold. Thus, a long line having large capacity will give a much larger discharge than a short line or one having a small capacity.

A good auxiliary protection in the case of long lines is to fasten a good-sized wire—8 or 10 galvanized-iron wire is about right—the full length of every fourth or fifth pole, letting the wire extend several inches above the pole. When a charged cloud comes near the line, these wires begin to quietly discharge the electricity from it. The line is also quietly discharged, and in this way the heaviest sparks through the lightning arrester are avoided.

PLANE MOTION.

George A. Goodenough.

Linear and Angular Velocity—Angular Velocities of a System of Bodies—Linear Velocities Determined From the Instantaneous Centers of the System.

PART III.

In our previous study of plane motion we have examined merely the changes in the positions of moving bodies, without reference to the time occupied in making such changes. The time has of course nothing to do with the character of the motion of a body; if it moves along a definite path from one position to another, the motion is the same whether the time required is a second or an hour. In many kinematic questions, however, time is an important consideration; frequently it is as necessary to know how fast a body is moving—that is, its *rate* of motion—as to know its path or direction of motion. In this article, therefore, we shall first turn our attention to the rate of motion, or the *velocity*, and later show how the velocities of various points of a system of moving bodies may be investigated by the aid of the instantaneous centers of the system.

Consider first the motion of a point in a straight line. If it is such that the point travels over equal spaces in equal times, the motion is said to be *uniform.* Suppose now that two points have uniform motions along a straight line, and that they travel equal distances in the same time; we say in this case that the points have equal linear velocities. Suppose, however, that in a given time, say 1 minute, the first point travels twice as far as the second; we say then that the velocity of the first point is double that of the second. In general, the velocities of several points having uniform motion are proportional to the distances traveled by the points in a given time. The usually adopted unit of velocity is the velocity of a point which, when moving uniformly, travels a distance of 1 foot each second; and the velocity of a point expressed in these units is found by dividing the space traveled by the time occupied. Thus, if a point moving uniformly travels 80 feet in 5 seconds, it travels at the rate of $\frac{80}{5} = 16$ feet in 1 second, or 16 times as fast as the point, which travels 1 foot per second; therefore, the velocity of the point is 16 units, or 16 feet per second.

If we denote by v the velocity of a point having uniform motion in a straight line, and by s and t, respectively, the space traveled and the time occupied, we have

$$v = \frac{s}{t} \text{ and } s = vt.$$

If we make $t = 1$, we have $v = s$; thus, the velocity is numerically equal to the space traveled in a unit of time. This is frequently given as the definition of velocity.

When a point has a variable motion in a straight line, that is, when it travels over equal portions of its path in unequal times, the velocity changes from instant to instant. Thus, the point at a given instant may move at the rate of 6 feet per second, and 2 seconds later it may move at the rate of 20 feet per second. Evidently, we cannot in this case define the velocity as the space traveled in a unit of time, since during the unit of time the velocity itself changes. We may say, however, that the velocity at any instant is measured numerically by the space through which the point *would* travel in a unit of time, if its motion remained uniform during this time. For example, we make the statement that at a given instant a point has a velocity of 7 feet per second. If the point should have uniform motion, we infer that during the next second the point will actually travel 7 feet. If, on the other hand, the motion is variable, we cannot infer any such thing; the point may travel 20 feet or only 5 feet during the succeeding second, and we can only assert that at the instant

under consideration the velocity of the point is such that, if it should continue to move uniformly with this velocity, it would travel 7 feet during the next second. It thus appears that velocity is essentially an instantaneous quantity.

In considering the motion of a point in a curved path, it is necessary to slightly extend our previous conception of velocity, so as to include the idea of direction as well as mag-

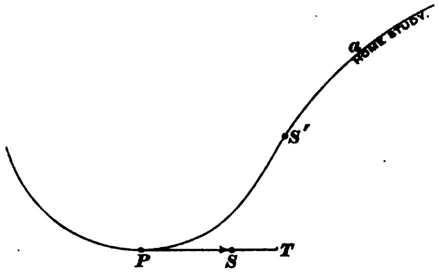


FIG. 1.

nitude. The direction of the velocity for any position of the point on the curve coincides with the direction of motion, and is given by the tangent to the curve at that point. Suppose that the curve a, Fig. 1, is the path of a moving point; then, when the point is at P, it is moving for the instant in the direction of the tangent PT. If, now, we imagine the motion to proceed uniformly in the direction of the tangent, the point would, during the next second, move to S, perhaps; therefore, PS may be taken to represent the velocity of the point in the position P. Actually, the point may be at the position S' at the end of the second, but this fact does not affect the truth of the statement that PS represents the velocity of the point at just the instant it occupies the position P. The point arrives at S' instead of S at the end of the second, because the velocity increases in magnitude and changes its direction during the second.

We now direct our attention to the case of a rigid body rotating about a fixed axis. Any point of such a body moves in a circular path, the center of which is the axis of rotation, and the radius of which is the distance from the point to the axis. Evidently, all points of the body have the same angular motion; that is, during any given time, the radii of all points turn through the same angle. In the case of uniform rotation, the quotient obtained by dividing the angle swept through by the time occupied is called the *angular velocity* of the rotating body. If the rotation is not uniform, the angular velocity at any instant is numerically equal to the angle through which the body would have turned in the next unit of time, if its rotation had been uniform during that time. We may take as the unit of angular velocity that of a point which describes a unit angle in 1 second. If we measure angles in degrees, the unit is 1 degree per second, and a body that makes a complete rotation of 360° in, say, 6 seconds would have $360 \div 6 = 60$ units of angular velocity. We take, however, as the unit angle one whose measuring arc is equal to the radius. Thus, in Fig. 2 suppose O to be the center of rotation, and let the angle POP' be so taken that the arc PP' is equal to the radius OP; then, POP' is the unit angle, and the body has unit angular velocity, if it so rotates that P describes the arc PP' in 1 second. This unit angle is called a *radian*. During a complete rotation, the point P travels a distance $2\pi \times OP = 2\pi \times PP'$; therefore, if the point makes one complete rotation per second, the angular velocity of the body is 2π radians per second, and if it makes N rotations per second, the angular velocity is $2\pi N$ radians per second.

Denoting the angular velocity by w, and the number of turns per second by N, we have the expression

$$w = 2\pi N.$$

The distance traveled per second by any point located r feet from the axis is $2\pi r N$ feet; therefore, the linear velocity of the point is $2\pi r N$ feet per second, or $v = 2\pi r N$. Substituting w for $2\pi N$, we obtain

$$v = r w.$$

Expressed in words, *the linear velocity of any point of a rotating body is equal to the product of the radius of the point and the angular velocity of the body.* It follows that the linear velocities of different points of the body are directly proportional to the radii of the points. If a point is at a unit's distance from the axis, that is, if $r = 1$, $v = w$. The angular velocity is therefore numerically equal to the linear velocity of a point at a distance unity from the axis.

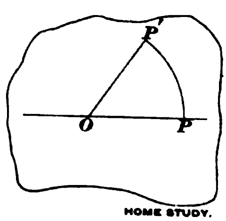


FIG. 2.

We are now prepared to attack the problem of finding the velocities of a system of bodies having definite motions relatively to each other. Suppose we have two bodies b and c, Fig. 3, that move relatively to a third

fixed body a, which we may suppose to be the page on which the figure appears. Let the bodies rotate about the centers $(a\,b)$ and $(a\,c)$, respectively, and let the instantaneous center of c's motion relative to b be the point $(b\,c)$ which, as we have seen, must lie in the straight line joining $(a\,b)$ and $(a\,c)$. Then, by definition, $(b\,c)$ is a point that has

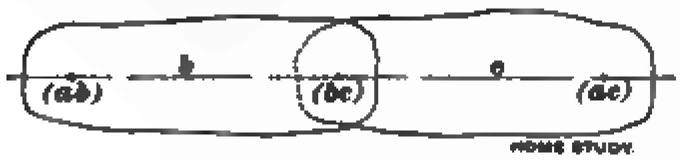


FIG. 3.

the same velocity whether it is considered as belonging to b or to c. Let us denote the velocity of this point by V; and let us also denote the angular velocities of the bodies b and c about their centers of rotation $(a\,b)$ and $(a\,c)$ respectively, by W_b and W_c. The linear velocity of $(b\,c)$ as a point of b is equal to the angular velocity of b multiplied by the distance from $(b\,c)$ to the center of rotation $(a\,b)$; therefore, $V = W_b \times (a\,b)\text{-}(b\,c)$. Likewise, considering $(b\,c)$ a point of the body c, $V = W_c \times (a\,c)\text{-}(b\,c)$. Combining these two values of V, we obtain

$$W_b \times (a\,b)\text{-}(b\,c) = W_c \times (a\,c)\text{-}(b\,c),$$

or

$$\frac{W_b}{W_c} = \frac{(a\,c)\text{-}(b\,c)}{(a\,b)\text{-}(b\,c)}.$$

As an example of the application of this principle, let us take the two gears b and c, Fig 4, attached to the frame a. The point of contact is the instantaneous center $(b\,c)$, and the angular velocities of the gears are

FIG. 4.

inversely as the distances of this point $(b\,c)$ from the centers of rotation $(a\,b)$ and $(a\,c)$, that is, inversely as the radii of the gears. Since, from the equation $w = 2\,\pi\,N$, the angular velocity is proportional to the number of rotations N, it follows that the number of rotations made by each of the gears b and c in a stated time is inversely proportional to its radius.

The linear velocity of any point on a moving body is readily found when either the angular velocity of the body or the linear velocity of a point on some other body of the system is known. Suppose, for example, that the linear velocity of a point B of the link b is known, and that we desire to find from it the linear velocity of a point C of the link c. It is assumed, of course, that we know the motions of the two bodies relatively to a third stationary body a. Using the symbols of the preceding paragraphs, we have

$$\text{lin. vel. } B = W_b \times B\text{-}(a\,b);$$
$$\text{lin. vel. } C = W_c \times C\text{-}(a\,c).$$

Hence,
$$\frac{\text{lin. vel. } C}{\text{lin. vel. } B} = \frac{W_c}{W_b} \times \frac{C\text{-}(a\,c)}{B\text{-}(a\,b)} = \frac{C\text{-}(a\,c)}{B\text{-}(a\,b)} \times \frac{(a\,b)\text{-}(b\,c)}{(a\,c)\text{-}(b\,c)}.$$

Thus, the ratio of the linear velocities of two

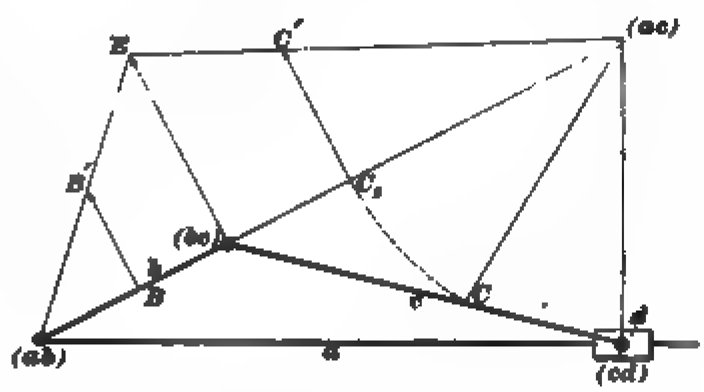


FIG. 5.

points belonging to different bodies of the system depends merely upon the relative location of the points and of the three instantaneous centers.

We will now apply these principles to a concrete example. In Fig. 5, we have given the familiar mechanism of the steam engine represented in a skeleton form. The link b is the crank, c is the connecting-rod, and the slide d represents the piston and crosshead. The instantaneous center $(a\,c)$ of the motion of the rod is readily found at the intersection of the prolongation of the crank and a line drawn through $(c\,d)$ perpendicular to the path of d. About this center every point of the rod is for the instant rotating with a definite angular velocity, and the velocity of any point of the rod is proportional to its distance from this center. Let us assume that the crank b rotates about its center $(a\,b)$ with a uniform angular velocity W_b; then, the angular velocity of the rod c about its center $(a\,c)$ is at once obtained from the relation

$$\frac{W_c}{W_b} = \frac{(a\,b)\text{-}(b\,c)}{(a\,c)\text{-}(b\,c)}, \text{ or } W_c = W_b \times \frac{(a\,b)\text{-}(b\,c)}{(a\,c)\text{-}(b\,c)}.$$

Suppose we wish to find the ratio of the linear velocity of the point C to that of the

point B. This can be done directly by measuring the distances B-(ab), C-(ac), (ab)-(bc), and (ac)-(bc), and substituting them in the preceding formula. Or, the following simple graphical method may be employed: From B lay off a length BB' to represent to some scale the velocity of B, and through B' and (ab) draw a straight line; through (bc) draw a line parallel to BB', cutting the line (ab)-B' in E; then, the length (bc)-E represents the linear velocity of (bc), since

$$\frac{BB'}{(bc)\text{-}E} = \frac{B\text{-}(ab)}{(bc)\text{-}(ab)} = \frac{\text{lin. vel. } B}{\text{lin. vel. } (bc)}.$$

Join E with (ac), lay off (ac)-$C_1 = (ac)$-C, and draw C_1C' parallel to (bc)-E; then, C_1C' represents the velocity of C, for, from the similar triangles $E(bc)(ac)$ and $C'C_1(ac)$,

$$\frac{C_1C'}{E\text{-}(bc)} = \frac{(ac)\text{-}C}{(ac)\text{-}(bc)} = \frac{\text{lin. vel. } C}{\text{lin. vel. } (bc)}.$$

$$\text{Therefore, } \frac{\text{lin. vel. } B}{\text{lin. vel. } C} = \frac{BB'}{C_1C'}.$$

The above method of investigating the velocities of a system of bodies having relative motion is perfectly general, and can be applied to any mechanism or combination of bodies however complicated, provided the necessary instantaneous centers can be found. Usually, the conditions are such that we can find all of the centers with more or less ease, though this is generally the larger part of the work.

GAS-ENGINE TESTING.*

E. W. Roberts.

THE REPORT—WORKING UP THE CARDS—THE USE OF THE PLANIMETER—COMPUTING THE HEAT WASTES—INTERPRETATION OF THE DIAGRAM.

AFTER the test is made and the data are obtained, the next thing to do is to write up the report. A convenient form for the report is given on the following page. The space before the words "gas engine" should be filled in with the maker's name, and "made by" should be followed by the name of the person or engineering firm that made the test and is responsible for the accuracy of the results. The next line should contain the name of the locality where the test was made, followed by the date.

The report should be made out in duplicate, one copy being kept by the party that makes the test, the other being given to the party for whom the test is made.

The first three dimensions are obtained by actual measurement, and need no explanation. The *piston displacement* is the product of the area and the stroke. The *clearance* is measured most readily in the following manner: Place the crank on the inner dead center, and close every opening but one, which should be on top. Then weigh a bucketful of cold water and pour through a funnel into the compression space, taking care that none is spilled and that the compression space is just full and no more. Weigh the water that remains in the bucket, and subtract this amount from the first weight. Divide the remainder by 62.5, and the result will be the clearance in cubic feet. Thus,

Let W = first weight;
w = second weight.

Then, $$\text{clearance} = \frac{W - w}{62.5}.$$

The percentage of clearance is found by dividing this result by the piston displacement.

The air used per hour is found by deducting the amount of gas used *per explosion* from the piston displacement, and multiplying this quantity by the number of explosions per hour.

The ratio of the gas to the air is the ratio of the quantity of gas supplied per hour to the quantity of air used in the same time. Thus, if there are 50 cubic feet of gas used per hour, and 400 cubic feet of air are used in the same time, the ratio of gas to air would be 50 : 400, or 1 : 8.

Comparisons with other engines should always be made as nearly as possible under the same conditions. A gas engine will lose more heat by radiation in a cold room than in a hot one, and a considerable difference in gas consumption will be noted when working with cold or with hot jacket water.

* *Begun in the June Number.*

REPORT OF TEST.

.... *Gas Engine.*

Made by ....

At .... *189*... .

Dimensions of Engine.	
Diameter of piston ... In.	....
Area of piston ... Sq. In.	....
Length of stroke ... Ft.	....
Piston displacement ... Cu. Ft.	....
Clearance ... Cu. Ft.	....
Clearance ... Per Cent.	....
Data.	
Duration trial ... Hrs.	....
Gas per hour ... Cu. Ft.	....
Air per hour ... Cu. Ft.	....
Ratio, gas to air ...	....
Jacket water per hour ... Lb.	....
Jacket water temperature, in ... F.°	....
Jacket water temperature, out ... F.°	....
Jacket water temperature, range ... F.°	....
Revolutions per minute, average ...	....
Revolutions per hour ...	....
Explosions per minute, average ...	....
Explosions per hour ...	....
Temperature exhaust ... F.°	....
Temperature room ... F.°	....
Length of lever arm ... Ft.	....
Brake load, average ... Lb.	....
Gas—Weight of cubic foot ... Lb.	....
Air—Weight of cubic foot ... Lb.	....

Mixture—Weight of cubic foot ... Lb.	....
Specific heat, gas ...	....
Specific heat, air ...	....
Specific heat, mixture ...	....
Heat value cu. ft. gas ... B. T. U.	....
Results.	
Work—Ft.-Lb. per minute ... Average	....
Work—Ft.-Lb. per hour ... Average	....
D. H. P. ... Average	....
Indicated M. E. P. ... Average	....
Indicated H. P. ... Average	....
Gas per I. H. P. ... Cu. Ft.	....
Gas per D. H. P. ... Cu. Ft.	....
Mech. Eff. D. H. P.÷I. H. P. ... Per Cent.	....
Friction Loss I. H. P.—D. H. P. ...	....
Heat Per Hour.	
Supplied by gas ... B. T. U.	....
Absorbed by jacket water ... B. T. U.	....
Exhausted ... B. T. U.	....
Absorbed in work ... B. T. U.	....
Radiation ... B. T. U.	....
Thermal efficiency ... Per cent.	....
B. T. U. per I. H. P. ...	....

For the comparison of engines working on different kinds of gas, the thermal efficiency of the gas is a much better basis than the gas consumption, for a gas engine that will develop 1 horsepower on 20 cubic feet of city gas would need 80 cubic feet of producer gas per horsepower; or, the same engine will develop 1 horsepower on 10 or 12 cubic feet of natural gas. In case the gas used for the several engines being tested is to be taken from the same source, a comparison of the gas consumption per horsepower is sufficient.

Taking the temperature of the water, as it enters and leaves the jacket, answers a double purpose. It enables the operator to regulate the temperature of the water during the trial, and is also a factor in the measurement of the loss of heat through the jacket. This loss of heat is of course not altogether the fault of the engine itself, much depending on the way the flow of water is controlled. The best makers nowadays advise the use of a circulating tank, in which the water soon reaches the boiling point, and then a minimum amount of heat is carried away.

The determination of the exhaust temperature is not so important in a partial test, as that of the jacket water, but it serves as a check on the indicator diagram.

The temperature of the room gives a clue to one cause of loss by radiation. It also should be subtracted from the exhaust temperature in the calculation of losses through the exhaust, because the temperature of the room is that of the air taken in by the engine and is usually very close to that of the gas, so it will give a sufficiently close approximation to the temperature of the entering charge. The heat carried in by this means should not, of course, be credited to combustion.

The readings having all been obtained, it is possible to trace the heat wastes from the calculated results and to discover the cause of any abnormal loss. Nothing but a proper interpretation of the indicator diagram will show up faults in valves or igniters.

Having learned, in a general way, what is being sought, the next thing to consider is the calculation of the results from the data

obtained. It is best to have a competent assistant to work up the results independently, the separate computations acting as a check upon each other. If the two results thus obtained agree, they may generally be considered correct.

To determine the brake, or delivered, horsepower, three things must be known: first, the pressure exerted at the end of the brake arm; second, the length of the arm;

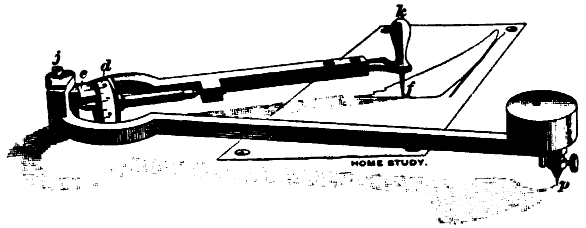


FIG. 9.

and third, the number of revolutions made by the crank-shaft in 1 minute. If the brake arm were permitted to move with the pulley against a pressure equal to that exerted on the scales, it would be giving that thrust through a distance, per minute, equal to the distance the end of the arm would traverse in that time. Now, it is evident that in one revolution the arm would describe a complete circumference, the length of which would be equal to $l \times 2 \times 3.1416$, where l is the length of the lever arm in feet; and the total distance traversed in 1 minute would be equal to $n \times l \times 2 \times 3.1416$, where n is the number of revolutions made by the crank-shaft in 1 minute. This total distance traversed multiplied by the pressure p gives the number of foot-pounds exerted in 1 minute; and, since the capacity to do 33,000 foot-pounds of work per minute is 1 horsepower, the formula for the delivered horsepower is

$$\text{D. H. P.} = \frac{p \times l \times n \times 2 \times 3.1416}{33{,}000}.$$

Since, during any trial in which the same brake is used throughout, the brake arm does not change, the value $\frac{l \times 2 \times 3.1416}{33{,}000}$ is the same for all readings. Ascertain this value once for all, and call it c. It then remains to multiply c by $p \times n$ for each separate determination. Suppose that $l = 6$ feet.

Then, $c = \frac{l \times 2 \times 3.1416}{33{,}000} = .001142$,

and

$\text{D. H. P.} = c \times p \times n = .001142 \times p \times n.$

It is generally advisable to keep the pressure p constant during a single run, in which case a new constant can be computed for each particular run which will include p. Calling this new constant C, it becomes

$$C = \frac{p \times l \times 2 \times 3.1416}{33{,}000}, \text{ or } C = c \times p.$$

In the ordinary form of prony brake, the length of the brake arm l is the distance from the center of the crank-shaft to the point where the knife edge exerts its pressure on the scale. This distance is denoted by L in Fig. 1 of this article (see June number).

The lever arm of the strap or rope brake, illustrated in Fig. 2, is the distance from the center of the shaft to the *center* of the strap or rope. For example, if the diameter of the pulley is 36 inches and the belt is $\frac{1}{2}$ inch thick, the brake arm will be $\frac{36 + \frac{1}{2}}{2} = 18\frac{1}{4}$ inches.

To compute the indicated horsepower from the indicator diagram, the average, or mean, height of the diagram must be found. The easiest and most accurate way to do this is to get the area of the diagram by means of a planimeter, and to divide this area by the length of the diagram. A planimeter suitable for this purpose is shown in Fig. 9. It consists of two arms hinged together by a pivot joint at j. One arm carries a recording wheel d which, rolling on the surface to which the card is fastened, while the outline of the diagram is being traced by the point k, records the area enclosed. The needle point p is fixed in the paper or drawing board, and remains stationary during the operation.

The indicator card should be fastened to a smooth table or drawing board which has been previously covered with a piece of heavy unglazed paper or cardboard. The point p should be placed far enough from the indicator card to enable the wheel to roll on the unglazed paper without touching the card, as it will slip if rolled over a smooth surface. Now set the zero of the wheel d opposite the zero of the vernier e. Then, with the tracing point f follow the line of the

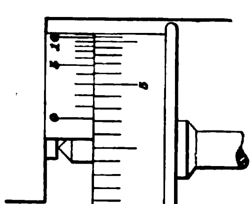


FIG. 10.

diagram carefully, moving the point in the direction of the arrow, and stopping exactly at the starting point.

The area is read from the record wheel and vernier as follows: The zero of the vernier will be opposite a certain point on the wheel;

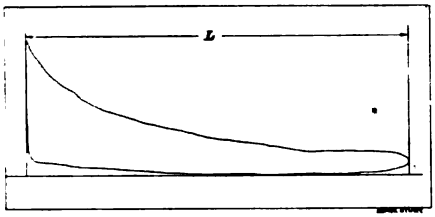


FIG. 11.

if it happens to be exactly opposite one of the division lines on the wheel, that line gives the exact area in tenths of a square inch. The zero of the vernier, however, will probably be between two of the division lines on the wheel, in which case write down the inches and tenths that are to the left of the vernier zero and add a third figure—which will be the nearest hundredth of a square inch—as follows: Find which one of the lines of the vernier is exactly opposite one of the lines on the wheel; then the line *on the vernier* will indicate the number of hundredths to be added to the reading already obtained from the wheel. An example of this is given in Fig. 10—the reading from the wheel being 4.7 and that on the vernier being 3 hundredths, making 4.73 square inches altogether. A thorough discussion of the vernier is given in HOME STUDY, June, 1896, article entitled "The Vernier."

To determine the length of the diagram, draw two lines just touching the diagram at its extreme limits, and perpendicular to the

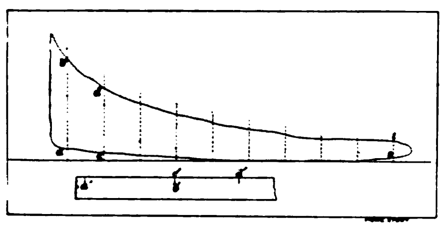


FIG. 12.

atmospheric line, as illustrated in Fig. 11. The length will be the horizontal distance L between these two lines. The area of the diagram divided by the length gives the mean height, or mean ordinate. This mean ordinate multiplied by the scale of the indicator spring gives the mean effective pressure, or M. E. P.

Suppose, for example, that the area a of a certain indicator diagram is 2.17 square inches, the length L 2.9 inches, and the scale s of the indicator spring 120 pounds. Then the mean ordinate is equal to

$$\frac{a}{L} = \frac{2.17}{2.9} = .748;$$

and M. E. P. $= .748 \times 120 = 89.8$ pounds; or, more directly,

$$\text{M. E. P.} = \frac{a}{L} \times s = \frac{2.17}{2.9} \times 120 = 8.98 \text{ pounds.}$$

If a planimeter is not available, the mean ordinate may be obtained by the method shown in Fig. 12. It is not as accurate, however, as the planimeter method. Divide the diagram horizontally into 10 equal lengths, and at the center of each length erect a perpendicular to the atmospheric line. Take a long strip of paper—the end only of which is shown in the figure—and mark off the distances $a\,b$, $c\,d$, etc., as shown at

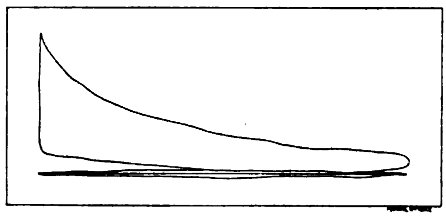


FIG. 13.

$a'\,b'$, $c'\,d'$. Divide the total distance from a to the last mark made by the number of divisions—10 in this case—and it will give the length of the mean ordinate. For instance, if the length from a' to t'—the last mark on the strip—is 7.48 inches the mean ordinate will be .748 inches.

The experimenter will frequently run across an engine making a diagram similar to that shown in Fig. 13, with a loop enclosing the atmospheric line. In such a case the area of the small loop should be subtracted from that of the larger diagram, before calculating the mean ordinate.

To compute the I. H. P., the following formula is used:

$$\text{I. H. P.} = \frac{P\,l\,a\,n}{33{,}000},$$

in which

$P =$ M. E. P.;

$l =$ length of piston stroke in feet;

$a =$ area of piston in square inches;

$n =$ number of explosions per minute.

The reader is asked to note particularly that the symbol n does not stand for *revolutions*

per minute, as in the similar formula for the steam engine, but for *explosions*. As in the calculations for the D. H. P.—the dimensions l and a being the same for all calculations—that portion of the formula including these terms may be computed once for all, and $\frac{l \times a}{33{,}000}$ put equal to a constant c.

The amount of gas per I. H. P. is found by dividing the gas consumed per hour by the number of I. H. P. The gas per D. H. P. is found in a similar manner, dividing the hourly consumption by the number of D. H. P.

The mechanical efficiency is equal to the D. H. P. divided by the I. H. P., or $\frac{\text{D. H. P.}}{\text{I. H. P.}}$. It is always less than 1, and is written either as an efficiency of, say, .87 or as 87 per cent.

The unit of measure of heat is the *British thermal unit*, usually abbreviated to B. T. U. One B. T. U. is the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit. The loss due to friction is the difference between the I. H. P. and D. H. P. Thus, I. H. P. — D. H. P. = the friction loss, in horsepower. The heat supplied by the gas per hour is the heat value of 1 cubic foot of the gas in B. T. U. multiplied by the number of cubic feet used in 1 hour; that is, if the heat value is 650 B. T. U. per cubic foot and the hourly gas consumption 50 cubic feet, the heat supplied to the engine per hour is $650 \times 50 = 32{,}500$ B. T. U.

The following computations of heat wastes are absolutely necessary only when making a complete thermal analysis of the engine. It is always best that such a test be made under the direct supervision of a competent engineer. The following outline is given in order that the reader may have sufficient insight into the process involved, to enable him to determine whether such a test is desirable in any specific case.

The heat absorbed by the water-jacket is equal to the weight of water passed through the jacket multiplied by the temperature range. The temperature range is the difference between the temperatures of the water when it enters and when it leaves the water-jacket. For instance, if the temperature of the entering water is 50° and that of the escaping water is 180°, then the temperature range is $180° - 50° = 130°$. Then if the weight of water passing through the jacket in 1 hour is 100 pounds, the heat carried away is $100 \times 130 = 13{,}000$ B. T. U.

To determine the heat carried away by the exhaust gases, the amount of heat taken up by a pound of gas must be known, and also the weight of the gas in pounds per cubic foot. The amount of heat taken up by 1 pound of gas is called its *specific heat*. Thus, if the specific heat is .2, 1 pound of gas would require but .2 B. T. U. to raise its temperature 1 degree Fahrenheit. City gas at atmospheric temperature and pressure weighs, on the average, .04 pound per cubic foot. Air under the same conditions weighs .078 pound per cubic foot. Air has a specific heat of .238; that of the city gas can usually, without serious error, be taken at .22. For accurate observations the figures must be determined for the particular kind of gas used. These quantities being known, the weight and the specific heat of the mixture, or charge, can be calculated quite readily, and the formula for the heat H carried away by exhaust is:

$$H = S \times w \times q \times (T - t),$$

where S = specific heat of the mixture;
w = weight of 1 cubic foot of the gas, in pounds.
q = quantity of the mixture exhausted per hour, in cubic feet;
T = temperature of exhaust ascertained by pyrometer;
t = temperature of the room.

The quantity of the mixture passing through the exhaust is found by multiplying the volume displaced by the piston by the number of explosions.

The heat absorbed in work is that delivered to the piston in I. H. P. The mechanical equivalent of a B. T. U. is 778 foot-pounds; hence, as a horsepower is the capacity to do 33,000 foot-pounds of work per minute, the formula for transforming the I. H. P. into B. T. U. becomes

$$\text{B. T. U.} = \frac{H.\,P. \times 33{,}000 \times 60}{778}.$$

The balance of heat that remains after subtracting the sum of the results of the above three calculations from the heat supplied by the gas is put to the credit of radiation.

The thermal efficiency is determined by dividing the heat absorbed in work by that supplied by the gas. The result is usually written as a percentage. Where two engines are to be compared, this result is the only basis of comparison that is absolutely fair and reliable, unless both engines are tested with gas of the same heat value. The B. T. U. per I. H. P. is equal to

$$\frac{\text{B. T. U. supplied by the gas per minute}}{\text{I. H. P.}}.$$

ARITHMETICAL PROGRESSIONS.

Antonio Llano.

LENGTH OF ROPE ON A CONICAL DRUM—HOW TO COUNT A PILE OF CANNON BALLS—GENERAL PROPERTIES AND APPLICATIONS OF ARITHMETICAL PROGRESSIONS.

IT IS often necessary to find the length of a rope wound around a conical drum, such as is shown in Fig. 1; and, conversely, knowing the length that the rope must have, as when a rope is needed that will reach to the bottom of a certain well or of a certain shaft, the dimensions of the drum must be so made that the required length of rope may be wound around it.

Let the drum and the number of turns of the rope be given, to find the length of the rope. In all practical cases of this kind, the rope winds very gradually, so that for each turn, as $B\,C\,D$, the point at the beginning and that at the end of the turn are very near each other, and the curve $B\,C\,D$ may be considered as practically a circle, having a diameter equal to $A\,B$. The problem, then, may be stated as follows: Given a conical drum (known in geometry as a *conical frustum*), and a series of circular sections

FIG. 1.

equally distant from one another, to find the sum of the circumferences of those sections.

In Fig. 2, $A\,B\,A'\,B'$ is the plan of the drum, and $A\,B$, $n'_1\,n_1$, $n'_2\,n_2$, $n'_3\,n_3$, etc. are the plans of the different circles. The two bases $A\,B$ and $A'\,B'$ of the drum, and its height $A\,H = B\,K$, are supposed to be known, as well as the number of circles; their common distance apart $B\,m_1 = m_1\,m_2 = m_2\,m_3$, etc. is not required, although it is easily found by dividing the height by the number of circles minus 1. We might calculate each of the diameters $n_1\,n'_1$, $n_2\,n'_2$, etc., find the corresponding circumferences, and add the results; but it would take too long to do this. Let $A\,B = D$ be the diameter of the lower base, and $A'\,B' = D'$ be the diameter of the upper base; let c, c_1, c_2, etc. be the lengths of the various circumferences, as shown, and D, D_1, D_2, etc. their respective diameters; also, let $m_1\,n_1 + m'_1\,n'_1 = x$. Then will $m_2\,n_2 + m'_2\,n'_2$ be equal to $2\,x$, $m_3\,n_3 + m'_3\,n'_3$ be equal to $3\,x$, etc., and we may write:

$$D_1 = D + x;$$
$$D_2 = D + 2x;$$
$$D_3 = D + 3x;$$
$$D_4 = D + 4x;$$
$$D_5 = D + 5x;$$
$$D_6 = D + 6x = D'.$$

Consequently,

$$c + c_1 + c_2 + c_3 + \ldots = \pi\,D + \pi\,D_1 + \pi\,D_2 + \pi D_3 + \ldots = \pi\,D + \pi\,(D + x) + \pi(D + 2x) + \pi\,(D + 3x)\ \ldots\ldots = \pi\,[D + (D + x) + (D + 2x) + (D + 3x) + \ldots\,]. \quad (1)$$

Here again we might easily find x, and perform the operations indicated; but it will be readily seen that if the number of terms inside the bracket were very great—say 30 or 40—the operation would be too tedious and there would be many liabilities to error. We notice that each term inside the bracket is formed from the preceding by the addition of a fixed quantity x. When, as in this case, we have a succession of numbers obtained from one another according to a certain law, the numbers are said to form a *series*.

The preceding series is called an *arithmetical series* or *arithmetical progression*. Before continuing the solution of our problem, we shall study the general properties of arithmetical progressions, and see if from them we can derive some rule by which the work of calculation can be shortened.

The general definition of an arithmetical progression is this: a succession of numbers each of which is formed from the preceding by the (algebraic) addition of a constant quantity, called the *common difference*, or simply the *difference*, of the progression. The following are examples:

1	2	3	4	5	6	etc.
5	9	13	17	21	25	etc.
72	65	58	51	44	37	etc.

In the first of these series, the common difference is 1: each term is obtained from the preceding by the addition of 1; in the second series, the difference is 4; and in the third, the difference is -7, that is, each term is obtained from the preceding by the algebraic addition of -7.

Let us take the series,

$$6\ \ 11\ \ 16\ \ 21\ \ 26\ \ 31\ \ 36\ \ 41\ \ 46\ \text{etc.},$$

whose difference is 5, and study some of its properties. The second term is equal to 6 plus the difference 5, that is, $11 = 6 + 5$; the third term is $16 = 11 + 5 = 6 + 5 + 5 = 6 + 2 \times 5$; the third term is $21 = 16 + 5 = 6 + 2 \times 5 + 5 = 6 + 3 \times 5$, etc. We see that *any term is equal to the first term added to the product of the difference by the number of terms preceding the term whose value is sought.* Thus, the value of the sixth term is $6 + 5 \times 5 = 31$; the value of the twentieth term would be $6 + 19 \times 5 = 101$.

If we consider a certain number of terms, say from 6 to 46, or nine terms, 6 and 46 are called the *extremes*. The sum of 6 and 46 is 52; the sum of 11 and 41 is 52; the sum of 16 and 36 is 52, etc.; that is, *the sum of any two terms equally distant from the extremes is equal to the sum of the extremes.* The reason for this is obvious; for in passing from 6 to 11 we add 5 to 6, but in passing from 46 to 41 we subtract 5 from 46, and we have

$$11 + 41 = (6 + 5) + (46 - 5) = 6 + 46.$$

Likewise,

$$16 + 36 = (11 + 5) + (41 - 5) =$$
$$11 + 41 = 6 + 46.$$

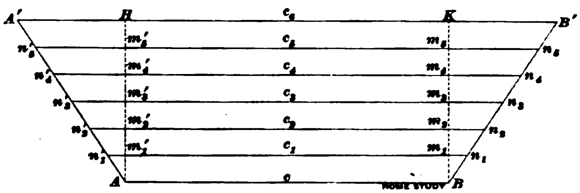


FIG. 2.

The next thing to find is the sum of the terms of the progression, which we shall call S. Writing the terms of the progression first in their natural order and then in an inverted order, and adding, we get the following:

$$\begin{array}{ccccccccc} 6 & 11 & 16 & 21 & 26 & 31 & 36 & 41 & 46 \\ 46 & 41 & 36 & 31 & 26 & 21 & 16 & 11 & 6 \end{array}$$
$$(6+46)+(11+41)+(16+36)+(21+31)+..$$

This sum is evidently equal to $2S$, and, as all the numbers included by the parentheses are equal, each being the sum of two terms equally distant from the extremes, we may write,

$$2S = (6 + 46) + (6 + 46) + (6 + 46) + \ldots$$
$$= 9(6 + 46);$$

whence, dividing both members by 2,

$$S = \frac{9(6 + 46)}{2} = \frac{6 + 46}{2} \times 9.$$

Therefore, *the sum of the terms of an arithmetical progression is equal to the mean of the extremes multiplied by the number of terms.*

The foregoing results are better expressed by means of general formulas, which will enable us to solve all the problems that may occur relating to arithmetical progressions. Let a and l be the extremes of a progression, d the common difference, and n the number of terms. Then the terms of the progression will be:

$$a,\ a + d,\ a + 2d,\ a + 3d,\ \text{etc.}$$

The value of the last term will be:

$$l = a + (n - 1)d. \qquad (2)$$

Conversely, if the last term is known, and also the difference and the number of terms, the first term is found from (2) by transposing:

$$a = l - (n - 1)d. \qquad (3)$$

The mean of the extremes is

$$\frac{a + l}{2};$$

therefore,

$$S = \frac{(a + l)n}{2}, \qquad (4)$$

or, since $l = a + (n - 1)d$,

$$S = \frac{[a + a + (n - 1)d]n}{2}$$
$$= \left[a + \frac{(n - 1)d}{2}\right]n. \qquad (5)$$

We may now return to the problem of the drum. Referring to formula (1), and denoting the length of the rope by L, we have:

$$L = \pi[D + (D + x) + (D + 2x) + (D + 3x) + ..]$$

The groups inside the bracket form an arithmetical progression whose first term is D, whose difference is x, whose number of terms is 7 (the number of circles), and whose last term is D' [since $D' = A'B' = KH + (KB' + HA') = D + 6x$]. Therefore, by formula (4),

$$L = \frac{\pi(D + D') \times 7}{2} = \frac{7\pi(D + D')}{2}.$$

If, instead of 7, we had any other number of turns, say n, we should have

$$L = \frac{\pi n(D + D')}{2},$$

or, remembering that $\pi = 3.1416$, nearly,

$$L = 1.5708\, n(D + D').$$

It must be understood that this is only

an approximate formula; it gives close enough results whenever the number of turns is very great, compared with the height of the drum, or when the grooves for the rope are very close together.

If the drum, instead of being conical, is cylindrical, then $D = D' =$ diameter of cylinder, and the formula for the length of the rope becomes

$$L = 3.1416\,n\,D.$$

If we take the natural numbers, 1, 2, 3, 4, 5, etc., it will be noticed that they form an arithmetical progression whose common difference is 1 and whose first term is 1. Let it be required to find the sum of the first n terms, that is, the sum of all the numbers from 1 to n. Here, the last term is equal to the number of terms n, and formula (4) gives

$$1 + 2 + 3 + 4 \ldots + n = \frac{(1 + n)n}{2}. \quad (6)$$

If, for instance, $n = 7$, we have:

$$1 + 2 + 3 + 4 + 5 + 6 + 7 = \frac{(1 + 7) \times 7}{2} = 28.$$

Formula (6) has several useful applications, one of them being to the counting of

FIG. 3.

elongated cannon projectiles. These projectiles are of circular cross-section, and are usually arranged in piles consisting of horizontal rows, each row having one more projectile than the one immediately above it (see Fig. 3). When the pile is complete, there is one projectile at the top, two in the next row, three in the next, etc., so that each projectile rests on two others under it. Evidently, the bottom row contains as many projectiles as there are rows (counting the top projectile as one row), and, as the number of projectiles in the successive rows is 1, 2, 3, 4, etc., the total number is found by counting the number of shot in the bottom row (which is the value of n), and using formula (6). In Fig. 3 there are 13 projectiles in the bottom row; therefore, the total number of projectiles is,

$$\frac{(1 + 13) \times 13}{2} = 91.$$

If some of the projectiles have been removed from the top of the pile, the remaining number of rows is equal to 1 plus the difference between the lower and the upper row. The extremes of the progression are, then, the number of projectiles in the upper and in the lower row, respectively, and the total number is found by formula (4). Thus, if the bottom row contains 35 projectiles, and the upper one 7, we have $n = 1 + 35 - 7 = 29$, and

$$S = \frac{(7 + 35) \times 29}{2} = 21 \times 29 = 609.$$

A great many of the practical rules and formulas used in engineering are derived by means of the differential and integral calculus; yet there are few of them that cannot be derived by algebraic methods, which, although a little longer than the methods of the calculus, are comparatively simple. Of this we have an example in Weisbach's *Theoretical Mechanics*, a standard and exhaustive work, in which the higher mathematics are seldom employed. For the understanding of a work of this kind, a knowledge of the properties and formulas of progressions is of great value.

A problem that frequently occurs in elementary mathematical mechanics is this: *To find the sum of the squares of a certain number of terms of the series* 1, 2, 3, 4, 5, etc., say the sum of the squares of the terms from 1 to n.

From the well known rules for cubing a binomial, we have:

$$\begin{aligned}
1^3 &= 1 \\
2^3 &= (1 + 1)^3 = 1 + 3 + 3 + 1 \\
3^3 &= (1 + 2)^3 = 1 + 3 \times 2 + 3 \times 2^2 + 2^3 \\
4^3 &= (1 + 3)^3 = 1 + 3 \times 3 + 3 \times 3^2 + 3^3 \\
5^3 &= (1 + 4)^3 = 1 + 3 \times 4 + 3 \times 4^2 + 4^3 \\
&\ldots \\
n^3 &= [1 + (n - 1)]^3 = 1 + 3(n - 1) + 3(n - 1)^2 + (n - 1)^3.
\end{aligned}$$

Adding these equalities by columns, and noticing that the terms in the last column cancel all the terms on the left-hand side of the equation, except the last, we get

$$\begin{aligned}
n^3 = 1 \times n &+ 3[1 + 2 + 3 + \ldots + (n - 1)] \\
&+ 3[1^2 + 2^2 + 3^2 + \ldots + (n - 1)^2].
\end{aligned}$$

The expression in the first bracket is equal to $\frac{n(n - 1)}{2}$ [formula (6)], and that in the second bracket is the sum of the squares of all the terms but the last. Therefore, if we call S_n the sum of the squares of all the terms, the preceding equation may be written:

$$n^3 = n + \frac{3n(n-1)}{2} + 3(S_2 - n^2).$$

Clearing of fractions and transposing,

$$\begin{aligned} 6S_2 &= 2n^3 + 6n^2 - 2n - 3n(n-1) \\ &= 2n^3 + 3n^2 + n \\ &= 2n^3 + 2n^2 + n^2 + n \\ &= 2n^2(n+1) + n(n+1) \\ &= n(n+1)(2n+1), \end{aligned}$$

and, finally,

$$S_2 = 1^2 + 2^2 + 3^2 + \ldots + n^2 = \frac{n(n+1)(2n+1)}{6}. \qquad (7)$$

Formulas may also be found for the sum of any other powers of the terms of an arithmetical progression; but they are not of so much value as formula (7). The applications of the latter formula are numerous; among the mechanical problems solved by it we may mention the determination of the moment of inertia of a section, and, among purely mathematical problems, the determination of the area of a parabola.

HOW TO READ A MECHANICAL DRAWING.*

G. Herbert Follows.

SECTIONAL VIEWS—CUTTING PLANES—SECTION LINING—THE USES OF BROKEN OR DOTTED LINES—VARIOUS METHODS OF ARRANGING THE VIEWS ON A DRAWING PLATE.

IT OFTEN happens that the outside of a machine, or part of a machine, is simplicity itself, compared with the inside. Hollow pieces, which it is impossible to explain by external views alone, are frequently used. The ram of a hydraulic jack—represented in Fig. 1—affords an example of such a piece. Externally, it is simple enough, but it is not as simple as it looks. Fig. 2 is a mechanical drawing of it, and Fig. 3 makes clear the true meaning of the two views in the mechanical drawing. It does not require a very powerful imagination to suppose the ram divided in halves through its center line, and one-half removed so as to expose the inside to view. This done, the "plan" in Fig. 2 is seen to correspond with the projection on the top plate *X*, *before the piece is divided*, while the "section on line $x\,y$" is the projection on plate *Z* of the exposed interior of the casting. The expression *section on line $x\,y$* means that the draftsman, when making that view, imagined that the part of the ram between his eye and the vertical plane passing through $x\,y$, was removed, so that he could see the shape of the inside of the casting. The imaginary plane passing through $x\,y$ is called a *cutting plane*.

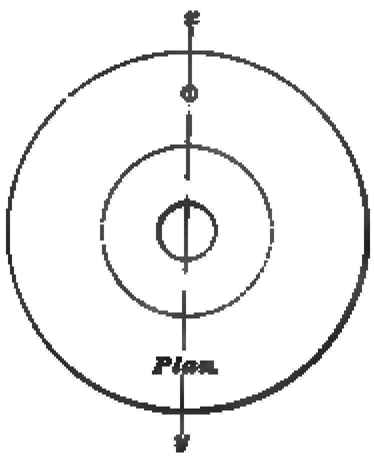


FIG. 2.

FIG. 1.

The parallel inclined lines on the sectional view are called *section lines*, and are never used except to indicate that the metal so shaded lies in the path of an imaginary cutting plane.

Sometimes the shape of the inside of a hollow piece is so simple that there is no need of a sectional view. The hollow cylinder shown in Fig. 4 is an example of such a piece. Here the broken lines show the shape of the inside with sufficient clearness, representing what *would* be seen if a cutting

*Begun in the May Number.

plane were used and the interior exposed to view.

In mechanical drawing, broken or dotted lines are also used to indicate outlines that would be visible if the piece represented were transparent, and as center lines, dimension and projection lines, etc. Fig. 5 should make these points clear.

Those of our readers who have followed this article since its commencement in the May number should now feel capable of reading with intelligence any

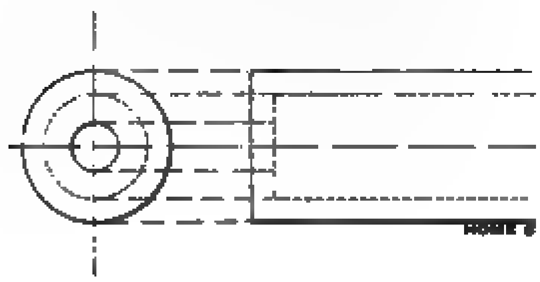


FIG. 4.

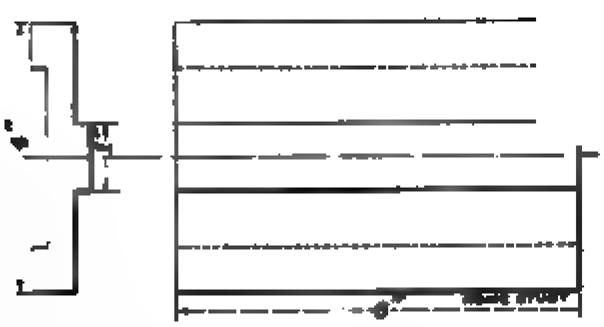


FIG. 5.

ordinary mechanical drawing, if the views are arranged as we have described them. As, however, this arrangement of the views —this strictly orthodox arrangement—is subject to modifications, we wish, now, to say something about the various methods that are in vogue in this country of grouping the several views on the drawing. In order to simplify our illustrations, we will deal with the piece shown in Fig. 6, which is a slight modification of the one explained last month as circular in plan, square in side view, and triangular in end view.

FIG. 6.

Many draftsmen, instead of arranging the three views in the strictly orthodox manner of Fig. 7, group them as in Fig. 8. Now, there is no need to be alarmed at this arrangement. It is quite allowable, and is done to get the side view and end view upon the same ground line *a b*—upright before the reader, as it were—and is often preferable to the strictly correct method of Fig. 7, especially where the drawing represents three views of a complete machine; and we have only to shut up the views, in Fig. 8, as indicated in the two views (*a*) and (*b*) of Fig. 9, to find that the original alphabet, as we have called it, remains undisturbed. The grouping shown in Fig. 10 is not only allow-

FIG. 3.

able, but correct; nevertheless, it is a rather foolish arrangement; it means that the draftsman made use of the side view of the object, from which to project the plan and end view, and the plan becomes no true plan, but a view from beneath; for this reason the arrangement is undesirable.

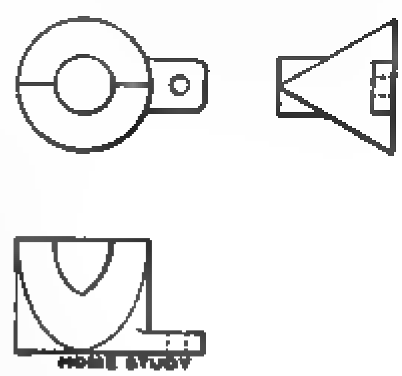


FIG. 7.

Sometimes draftsmen group the views as shown in Fig. 11. This arrangement, though frequently met with, is far from being orthodox; here the end view is a projection from the side view, and represents the end nearest to it; to be consistent, therefore, the plan *b* should represent the *under* side of the piece and not the top side, as shown. However, the man who understands the alphabet and language of

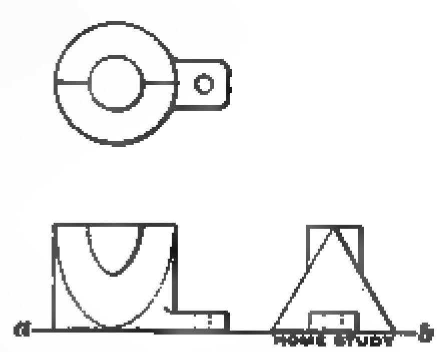


FIG. 8.

mechanical drawing can make allowance for errors of this kind, just as the recipient of a letter containing the word *slepe* understands that the writer made a mistake in the arrangement of the letters of the alphabet and really meant *sleep*. In fact, so long as the views are marked "plan," "side view," etc., no intel-

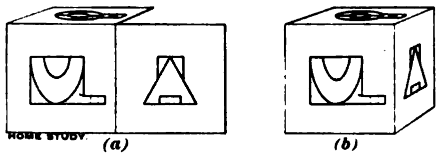


FIG. 9.

ligent reader should find any difficulty in understanding what the draftsman meant.

Before concluding, we wish to warn every beginner against resorting to the trick of folding a drawing plate in any way—as in Fig. 9, for instance—under the impression that this helps him to read the drawing correctly. If the views happen to be arranged as in Fig. 4, it won't do any harm—in fact, the beginner may think that it really helps him; but if they are arranged in any other manner it will falsify the meaning of the whole drawing or make it absolutely nonsensical, so that he will be unable to make either head or tail of it.

First of all find out, from an examination of the views, in what direction the draftsman imagined he was looking at the object when he made the view you are reading. If the views are grouped as in Fig. 11—and this arrangement is used exclusively in some drafting rooms, because it leaves the right-hand corner of the sheet open for the title, and for any written instructions which the draftsman may wish to put on the drawing—make a mental note of the fact that, as in Fig. 12, view *A* is a side view, that view *B* is the plan as seen when looking in the direction of the arrow *x*, and that view *C* is the end view as seen when looking in the direction of the arrow *y*.

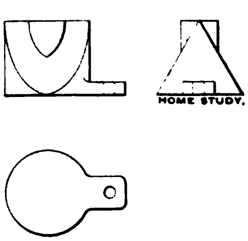


FIG. 10.

Here the reader will perhaps say, "If this is so, what is the use of the 'glass-case business' that so much has been said about?" If he does, let him read the first parts of this article again and digest them more thoroughly. The glass case should enable the beginner to understand what a mechanical drawing *is*, what a *projection* is, what a *side view* is, what an *end view* is, and what a *sectional view* is; in fact what *any* kind of a view is and really means. When he has absorbed these ideas, he has no further use for the glass case; he doesn't need it; he should feel that he is no longer a novice, but ready and able to read any mechanical drawing—no matter how the views are arranged, or how many sectional or special views there are of the piece or machine represented.

We hinted at the commencement of this article—in the May number—that the ability to read a mechanical drawing is a necessity to the majority of our readers.

We did not mean by this that most of them have frequent occasion to *work* from drawings, there being many other ways in which those who can read a mechanical drawing are far ahead of those who can not—in the reading of technical literature, for instance; whether in the form of text-books, educational magazines, or trade journals. In all of them the mechanical drawing is frequently used and is often far more necessary than the accompanying few words of explanation; while even the daily papers contain plans and sectional views, etc., of the latest inventions of popular interest.

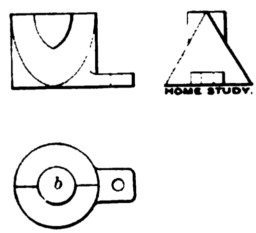


FIG. 11.

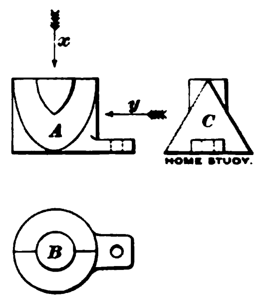


FIG. 12.

Again the man who understands this universal language of lines, is able after examining a structure of any kind, to carry away a clear idea of its proportions and construction, because he involuntarily forms a mental picture of the several views of it.

Nor is this all. *Reading* a language leads naturally to *writing* it, and the use of drafting instruments becomes a matter of mere detail; skill in the manipulation of T square, triangle, compasses, and pencil being soon acquired by any one who will but stick to that well known road to "handiness"—patient practice.

PHOTOGRAPHY FOR AMATEURS.

George F. Lord.

The Outfit—The Dark Room—A Home-Made Lamp—The Developer.

WE SHALL endeavor to discuss this subject in such a manner that a person entirely ignorant of both the theoretical and the practical side of photography may find here helpful suggestions and directions. We shall not try to be "scientific," but to clearly describe methods of producing good photographs at the least possible expense and by making use of such resources as the average amateur has at hand or can easily procure.

In purchasing a camera, it is well to bear in mind that the more nearly it approaches that which the professional photographer uses, the more likely we are to succeed. The amateur who starts out with a black box under his arm and a book of directions in his pocket, expecting to get fine results by pointing the said box at an object and then pushing a button, will probably be disappointed in the majority of cases. There is always more or less guesswork connected with one of these machine cameras. Many of them have no other means of focusing than a graduated scale and an indicator on the outside of the box. We are told that, if an object is 100 feet away, the indicator should be placed at the point marked "100" on the scale, and that a sharp picture will then be obtained. But, as it requires long practice to accurately estimate the distance of an object; many of our pictures will be "out of focus." Again, although such cameras are provided with "finders" to locate the view or image cast on the sensitive surface, yet many an otherwise good negative is spoiled because only half the object desired is on its surface.

Both of these difficulties may be obviated by purchasing a camera which has a ground glass for focusing. With this we can locate the view just as we want it on the finished picture, and focus sharply without regard to the matter of distance—or, rather, our *judgment* of distance. The ground glass is also a great aid in determining the length of time of the exposure. By noticing the comparative dimness or brilliancy of the image on the glass, we are soon able to judge accurately the necessary length of exposure.

Sensitized celluloid films are very convenient for some purposes, but they are difficult to handle while developing and printing; good dry plates will be found much more satisfactory.

To sum up: We advise the purchase of a folding camera, capable of carrying one or several double 4-inch × 5-inch plate-holders, and furnished with a good achromatic lens, ground glass for focusing, movable diaphragms, and a shutter that can be used for both time and instantaneous exposures.

A good camera answering to the above description is listed at $10.00, but can be bought in most places at a discount of 15 per cent., making the net price $8.50.

A tripod for supporting the camera is necessary for some classes of work, but the economical amateur can get along very well if he exercises a little ingenuity and uses some available support, such as a box, chair, or fence post.

Dry plates are sold in boxes of one dozen, ranging in price from 40 to 60 cents per box of the 4-inch by 5-inch size. It pays to get good plates, as the loss of one negative through the use of an inferior plate amounts to much more than the extra price per dozen of good ones. The box containing the plates must not be opened outside of the dark room.

The following chemicals will be necessary:

1 oz. pyrogallic acid	$0.35
1 lb. sulphite soda (crystals)	.15
1 lb. carbonate soda (crystals)	.10
1 lb. hyposulphite soda	.05
A solution of bromide of ammonia	.10

Two trays are needed: a developing tray of hard rubber—large enough to hold one plate—and an earthenware tray for "fixing," large enough to hold two or more plates. Both trays might be of the same material, but it is better to have them as suggested, in order to avoid any possibility of mistaking one for the other. If they are alike, label one "Hypo," and the other "Pyro." Always use the pyro tray for developing, and the other for fixing.

Two glass "graduates" will be necessary, one having a capacity of 4 fluid ounces and the other, 1 fluid ounce.

The lamp for the dark room may be either bought or made. Do not buy a lamp with a single plate of red glass in front. It should have an orange-colored plate back of the red; the light then transmitted is more agreeable to the eyes, and is not likely to "fog the plate." A good lamp is rather expensive to buy, so we may save money by making one.

Procure a wooden box with a sliding cover, such as is used to hold school crayons. Remove the cover, and cut the tongue away from each side so that it will fit snugly inside the box; then cut off a piece about one inch shorter than the depth of the box, as shown at *a*, Figs. 1 and 2. Next cut two strips of stout black or dark-red paper ¾ inch wide and 1 inch shorter than the inside width of the box, and crease them as indicated in Fig. 3, making the short leg ¼ inch long, and glue them—along this ¼-inch leg, as at *b* in Figs. 1 and 2—across the under side of what may now be called the *shelf a*, letting one strip reach to the right-hand edge and the other to the left-hand edge of the shelf; thus the ¼-inch leg of each strip will hang vertically downward. Now nail the shelf to within ½ inch of the bottom of the box, keeping the rear edge far enough from the back of the box to insure a good supply of air to the flame, and in such a position that the front edge of the shelf projects slightly, as shown. Glue a piece of ruby cloth—which can be purchased at any photographic supply store—to the projecting edge, letting it hang down to the bottom of the box, as at *d*, Fig. 4; this prevents the escape of any reflected rays of light.

In the top of the box cut a round hole *c* to fit a small tin can from which the ends have been removed, as at *g* in the figures. Then line the under side of the top with tin, leaving an opening under the hole just made, and bend the cover of a large can so that when placed over the chimney *g* the opening is but partially closed. For the candle holder, cut and bend a piece of tin as shown at *f* in Figs. 1 and 2. The front of the box consists of a plain sheet of glass, upon which is pasted a piece of the ruby cloth already mentioned.

Fig. 1.

Fig. 2.

Fig. 4.

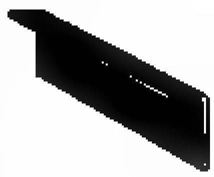


Fig. 3.

This lantern will give a safe, steady light, and will not warm a dark room nearly as much as will a kerosene lamp. Make all the joints good, so that no white light can escape. Do not use wax candles, as they soften and tip over as soon as the box becomes warm. A lamp made according to these instructions is the only one the writer has ever used, and it gives good satisfaction.

A rack for drying plates is very convenient, and can be bought for a few cents.

Having procured an outfit, it is necessary to provide a suitable place in which to carry on the chemical operations necessary for the production of a photograph. Since, in many of these operations, white light or light having actinic or chemical rays would be ruinous, it is necessary to have a "dark room."

While it is possible, at night, to make use of an ordinary room, it is much better to arrange a closet for the purpose. In Fig. 5 is shown a way of placing some shelves in a closet, which will be found convenient and economical of space. In the writer's dark room the two middle shelves were the sides of a box that happened to be just the width of the closet. It was merely raised to the proper height and nailed against the wall. The top shelf is for the drying rack, unexposed plates, and extra chemicals. The middle shelf holds the lamp, developing tray, graduates, and chemicals used while developing. The tray containing the fixing solution

Fig. 5.

and a dish of water occupy the lower shelf. The dark room must be *absolutely* dark. It should be tested by stepping inside and closing the door—the red light being out. At first it may appear quite dark, but soon a beam of light will be seen streaming in at the keyhole, another under the door, and half a dozen others through various crevices. These openings must all be stopped up. A strip of cloth tacked on around the edge of the door will usually suffice to stop light coming in there. The key will probably stop up the keyhole, and should be on the *inside* of the door. Always lock yourself in, and avoid the disastrous consequences of a sudden flood of daylight, as some member of the family rushes in after his best coat. Your plates and chemicals should be kept in this room if its temperature does not vary greatly from 60° Fahrenheit. If your developer gets too cool, it will not act; if too warm, it will fog the plate.

As soon as the dark room is arranged, the amateur is generally very impatient to load the plate-holder and proceed to "take a picture." But, as the developer should stand a while before being used, it is best to prepare the proper solutions and have all in readiness to develop the exposed plate.

To contain the solutions two bottles will be needed, each large enough to hold about 22 ounces of water, one dark-colored bottle (preferably dark brown), and a small bottle for the bromide of ammonia. Into one bottle pour a saturated solution of the hyposulphite of soda, that is, water which holds in solution all of the hypo that it can dissolve. Label this bottle "Hypo." None of this solution must ever become mixed with the developer as it would spoil the latter, and after handling it or its solution, the hands should be thoroughly cleansed.

For the developer two solutions are needed, as follows:

PYRO SOLUTION

Water (as pure as can be had)	6 fluid ounces.
Pyrogallic acid	½ ounce.
Sulphuric acid	2 or 3 drops.

The sulphuric acid is not necessary, but it is good.

The pyrogallic acid is a cotton-like powder put up in tin cans of 1 ounce each. Pour a couple of ounces of water into the graduate and stir the acid into that, as it is difficult to put it into the bottle in a dry form. Put this solution in the brown bottle and label "Pyro."

SODA SOLUTION.

Water	20 ounces.
Sulphite soda (crystals)	1 ounce.
Carbonate soda (crystals)	½ ounce.

Put in a large bottle and label "Soda."

The solution of bromide of ammonia can be had at the drug store.

The developer must not be mixed until it is to be used, as it will not keep when mixed.

(*To be Continued.*)

CURRENT TOPICS.

Mrs. Frederic R. Honey.

Spain and Cuba.

THE relationship between Spain and her island possessions of Cuba and Porto Rico, as mother country and colonies, dates back almost to the discovery of America. No other spot of land, discovered and colonized in this western world, remains in the hands of its original European possessor, and these islands are the sole remnants left to Spain of the magnificent American empire over which her flag once waved, far exceeding in extent that of Rome in the past, and almost equaling that of Great Britain at the present day.

Cuba was discovered by Christopher Columbus in the course of his first voyage to the West Indies, on October 27th, 1492; and to the day of his death the great navigator believed that the island, which he described as "the goodliest land that eye ever saw," was part of the western continent. It was left for his son, Diego Columbus, to found a colony in Cuba, which has been held ever since as a Spanish possession, and is proudly called the Pearl of the Antilles, the Ever Faithful Isle.

Like most of the great enterprises which the world has seen, the maritime discoveries of the 15th and 16th centuries were not the result of a mere love of adventure or the pursuit of an idea—they owed their origin to the need for an expansion of trade and commerce. At the end of the 15th century the Turks controlled the Levant, the eastern end of the Mediterranean. They interfered with the passage of vessels in these waters, and thus blocked the road towards the shortest land route to Persia, the Indies, and the riches of the East. Spain and Portugal, whose geographical position inclined their inhabitants to maritime enterprises, sought for freer access to the countries which were regarded as an inexhaustible mine of riches. The Portuguese sailed southward, and eventually eastward, rounding the south of Africa, and thus reached their goal by traveling in the familiar direction. Under the auspices of Spain sailed the man of genius who had already conceived of the world as a sphere, and who proposed to approach the Indies and Cathay (or China) from the other side; and the success of his experiment revolutionized the Old World.

Free trade was not yet dreamed of—the doctrine of "the open door" (as yet received by many with scant favor) is a product of the 19th century—and, as it was only too evident that others would follow in the track of the man who had thus showed the way to new sources of wealth, steps were taken to secure to the respective nations the exclusive advantages of their discoveries. In those days it was claimed that the pope had sovereignty over all heathen lands, and could dispose of them at his will. An imaginary line was drawn from the North to the South Pole, a hundred leagues west of the Azores and the Cape Verde Islands, and decrees were granted by Pope Alexander VI by which all seas and lands, discovered or to be discovered, to the east of the line should be the property of Portugal, and those to the west of the line should be the property of Spain. A very neat and simple method of disposing of a large portion of the earth's surface.

Spain thus came into nominal possession of all North and South America, except a part of Brazil, which was within the hundred-league limit. Over a very large portion of this vast territory she established some degree of authority, and the extent of her empire is proved by the wide limits within which the Spanish language is spoken today. Through the whole of South and Central America, from Patagonia to Mexico, except in Brazil, it is a familiar tongue, and until the present century it was also spoken by the white population of North America west of the Mississippi.

Spain believed that the papal grant included water as well as land, and that she was the owner of most of the Atlantic Ocean. Thenceforward she regarded foreign vessels, intruding into these seas for purposes of exploration or of commerce, as pirates, and treated them accordingly. But other maritime nations laughed at her pretensions; she fought them on the seas; they retaliated by attacking her American colonies; and Cuba, so easily accessible, often suffered at the

hands of foreign enemies. Havana, with its large and fine harbor, endured many vicissitudes. It was plundered by pirates; it was twice taken and burnt by the French; and in the 18th century it was captured by the British, who, after holding it for a year, restored it to Spain in 1763, in exchange for Florida. Since that time Cuba has suffered from no external foes, but her internal dissensions have been endless, and the mother country has proved herself unequal to the task of maintaining peace and order.

Efforts have been made in the direction of improvement; the office of captain general, which is one of almost supreme authority in the island, has often been filled by able and well intentioned men; modifications have been made in the tariff laws, which for many years confined trade to Spanish ports, and for most of that time to only two of such ports, Cadiz and Seville; there is greater freedom of the press; a more just administration in the courts of law; and an arrangement for the establishment of a form of representative government by suffrage has been made. But these changes are attempts to efface sad memories, and they have failed to restore tranquility to Cuba. They leave many grievances unremedied. The taxation is oppressive, and the government does so little for the development of the country that there are still millions of acres of uncleared forest, and great mineral resources unused which might be adding to the wealth of the people. So defective is the system of popular education that the large majority of the inhabitants are illiterate. Among the whites 68 per cent., and among the whole population 76 per cent., cannot read or write. The sanitary conditions of Havana and of other Cuban towns are bad in the extreme.

That the reason for such failures lies in the constitution and nature of the governing power, which has already shown its incapacity to keep its once vast colonial empire, is an inevitable conclusion. The loyalty of a subject people can be secured only by giving them laws under which they can live in safety and peace. But Spain has governed her colonies exclusively for her own benefit. Her whole idea has been to get as much as possible from them, with little regard for their own needs. Gold was the object of her 15th century adventures, and she expects to acquire gold in much the same way at the end of the 19th century; for it is Spain's misfortune that she does not learn and she does not forget, and thus the government, until very recent times, has been regulated by the harsh maxims and ideas of four hundred years ago.

Pride is recognized as one of the leading characteristics of the Spaniards, and to this quality may be traced most of the ills which have attended their colonial rule, as illustrated in Cuba. They are proud, hence they believe that they alone are fitted to fill important positions in the government of the island. Cuban labor must be used for their benefit; Cuban trade must minister to the glory of Spain; Cuban needs, in the way of sanitation and education, are of little consequence. The Spaniards hold aloof from native-born Cubans, as if they felt themselves to be of a superior race, even when the colonists are of almost pure Spanish blood. Pride and cruelty go hand in hand; and the cruelty of the Spaniards is proverbial. Their hearts are steeled against pity at the sight of suffering, if by its means they hope to accomplish their end. Pride makes them impose the religion, which they profess, on all dependent or subject races, enforcing their will by persecution, if gentler measures do not immediately succeed. Spanish cruelty towards the native inhabitants of Cuba, which resulted in their virtual extinction in the 16th century, is a matter of history. Unless they would profess conversion to Christianity, these natives were accounted unfit to live under the rule of the "most Christian king" of Spain. The slightest reaction on the part of the Cuban of negro blood to pagan superstitions and customs, such as the voodooism which is known to exist amongst the negroes of the Southern States, antagonizes the ruling classes, and results in various forms of persecution, even at the present day. The inquisition, than which no more cruel and terrible tribunal has ever been known in history, flourished in Spain on account of this proud fanaticism, and in its turn increased and stimulated these characteristics in the race. It was decreed that no one should be tolerated in the kingdom who did not promise obedience to the church. In consequence, the Jews and the Moors, in the 15th and 16th centuries, were banished from Spain, to the great economic loss of the country; for with them were lost the most skillful and industrious artisans, and the best agriculturists and cultivators of the soil. The persecuting power of the inquisition was extended to the American colonies, and pagan natives and Protestant Christians fared alike at the hands of its officers. The Spaniard's pride cannot stoop to conciliation or compromise when difficulties

arise; he can only conquer or die; and he dies bravely, and has often shown the world that he will lay down his life rather than yield—a fine and noble trait, when death is to be met in a good cause, but a fatal temper of mind for one who would rule men in these days when the echoes of songs of freedom fill the air.

The days of Spain's rule on this continent are nearing their end. She once played a great part on the world's stage; time was when she held the balance of power in Europe; this country can never forget that Spanish ships discovered a New World; literature, art, and science have all been worthily served by her; yet her story is written on the darkest pages of modern history, and there are few besides her own sons who will sincerely mourn her fall. And, though troublous days may yet await Cuba, we may well hope and believe that from the ruins of that island's hard past there will spring a happy and prosperous future.

THE SPANISH-AMERICAN WAR.

May 1st, 1898. A naval engagement in Manila Bay, Philippine Islands, between American fleet, six vessels, Commodore Dewey, and Spanish fleet, eleven vessels, Admiral Montojo, supported by shore batteries. American loss, 8 wounded; Spanish loss, 11 vessels, and from 800 to 1,000 killed and wounded.

May 2d. Manila blockaded.

May 4th. Battleship Oregon and gunboat Marietta sailed from Rio de Janeiro.

May 5th. Supplies for Cuban insurgents landed near Mariel.

May 6th. Great Britain refused to take part with European powers in intervention between Spain and the United States.

May 7th. Batteries at Havana fired on gunboat Vicksburg and revenue cutter Morrill.

May 11th. Cruiser Marblehead, with gunboat Nashville and others, bombarded Cienfuegos, destroyed lighthouse, fort, and cut cables. American loss, 1 killed, 7 wounded; Spanish loss, 360 killed, wounded unknown. Battle off Cardenas, between gunboats Machias and Wilmington, torpedo boat Winslow, and revenue cutter Hudson, and three Spanish gunboats, supported by shore batteries. American loss, 5 killed, 5 wounded. Winslow disabled. Spanish loss unknown.

May 12th. American vessel sinks Spanish gunboat off Iloilo, Philippine Islands. Forts at San Juan, Porto Rico, bombarded by Admiral Sampson; battleships Iowa and Indiana. American loss, 2 killed, 7 wounded; Spanish loss (reported), 20 killed, 60 wounded.

May 17th. Spain declines to forbid privateering. Cruiser Montgomery fires on Spanish gunboats off Nunevitas.

May 19th. North Atlantic squadron (Sampson) and flying squadron (Schley) effect a junction. Oregon reported safe by Secretary Long. Spanish fleet reported at Santiago de Cuba, having succeeded in eluding the American fleet in the passage across the Atlantic.

May 20th. Spain embarked troops at Cadiz for the Philippine Islands.

Neutrality has been guaranteed by the governments of Austria, Turkey, and Japan.

Spanish vessels captured: April 29th, Argonauta, by gunboat Nashville; April 30th, Mascota, by torpedo boat Foote; May 5th, Lola, by despatch boat Dolphin; May 7th, Espana, by revenue cutter Morrill; May 9th, Severita, by despatch boat Dolphin; May 12th, Rita, by auxiliary cruiser Yale, and gunboat Callao, off Manila; May 17th, gunboat Leyte, off Manila. Other small vessels have been taken, chiefly fishing craft.

Our record closes on May 20th.

THE CANNING OF VEGETABLES.

SELECTION OF SEED—PREPARING THE GROUND, AND SOWING—MOWING—SHELLING, ASSORTING, WASHING, BLANCHING, AND CAN FILLING—THE BRINER AND THE PROCESS KETTLE.

HAVING received inquiries regarding the canning of vegetables, we publish the following description of the manner of growing and handling green peas, and the process of packing the same, as employed in the United States. We are indebted for the information to Francis H. Leggitt & Co., of New York City, who tell us that tomatoes, corn, beans, and berries are handled in much the same manner, the variations being in the time occupied in the processes; each vegetable or fruit is given as little time in the kettle as will safely preserve it.

"Great care is taken in the selection of the seed for planting peas for canning purposes, the finest quality that can be obtained being used; of course, there are several varieties of seeds. Generally, the seed is bought of seed growers who have had long experience in growing peas for canners' use.

"The seed is planted at different times, so as to have the peas mature at successive periods, thereby enabling the canner to handle the peas as conveniently as possible. The ground is specially cultivated, being plowed in the fall or early in the spring, harrowing first with a disk harrow and following with a smoothing harrow, until the soil is thoroughly pulverized to a depth of 5 or 6 inches. On most land, fertilizer is used very extensively—from 300 to 600 pounds per acre of ground. This fertilizer—suitable for growing peas—is drilled in with the peas when planting.

"The peas are sometimes planted in rows, but experience has proved that the best results are obtained by sowing broadcast, using a regular wheat drill for planting, sowing about 3 bushels of seed to the acre, and rolling the ground as soon as the seed is planted.

"As soon as the peas begin to appear out of the ground they are harrowed with a smoothing harrow, which breaks the thin crust of the ground, and also destroys the small weeds. This is generally repeated in the course of a few days. Great care is taken, in harvesting the peas in vines, not to allow the peas to get too old or too large.

"When in condition for canning, the peas are mowed—sometimes with the scythe, but mostly with the mowing machine, just as standing hay is cut in the field; they are then loaded upon wagons, and taken to the viner and sheller, a machine which threshes the peas out of the pods. As the peas are shelled, they fall through the perforated rubber sides of the machine onto an inclined traveling apron or belt which carries over the chaff, or small particles of pods and vines, allowing the shelled peas to run down the apron to a receptacle or trough at the foot thereof.

"The above is the most advanced method of shelling peas; the old method, that is used in the cities to the present day, is to have the peas picked by hand from the vines in the field, then shipped to the canning houses, shelled there by the pod huller or sheller, after which the chaff is separated as already described. The shelled peas are then taken to the assorter, or separator, and the small, tender peas are separated from the large. As many sizes as desirable may be obtained. The smaller the peas the more desirable and more valuable they are for canning.

"From the assorter, the peas are conveyed to the washer, a machine cylindrical in shape, which runs in water, whereby the sand, dirt, and the rank, green taste of the juice of the vines and pods are thoroughly removed.

"From the washer the peas are conveyed to the blanching tubs—the first process in the preserving of the peas. The process is to dip the peas in water, allowing the water to come to a boiling point for certain lengths of time, according to the condition and age of the peas; then to the separator, where all the skins and split peas are separated from the whole peas; then to the can-filling machine, where the peas are measured and an accurate amount is placed in each can automatically; then to the briner, or syruper, where the liquor (simply salt and water) is run in the can to preserve the flavor of the goods in processing; then to the capping

machine, where the cans are sealed perfectly air-tight before going to the process kettles. The process kettles are large sealed retorts, in which the goods are subjected to a steam heat of about 240 degrees Fahrenheit for from 25 to 35 minutes, according to the age of the peas.

"From the process kettles they are immersed in cold water, cooling the cans as quickly as possible, before going to the warehouse to be labeled, boxed, and stored or shipped.

"The writer has known of peas being canned and boxed ready for shipment in two hours from the time the vines were cut in the field."

THE COOKING OF WHOLESOME MEALS.

Mrs. Henry Esmond.

How to Choose a Beef Roast—The Preparing and Cooking of Asparagus, Green Peas, Green Corn, and Spinach.

BILL OF FARE FOR DINNER.
Roast Beef and Gravy.
Asparagus on Toast. New Potatoes and Cream.
Green Peas, Spinach, Green Corn.
Tapioca Cream.

Roast Beef.—Good beef should be bright red, with a thick layer of yellowish-white fat on the outside. The ribs or the second cut of the sirloin is the best for roasting. For a family of five or six a two-rib roast is best. This weighs 4 or 4½ pounds. The price runs from 16 to 20 cents a pound. Have the bones taken out and the meat tied into a round shape. As soon as any meat is delivered from the store, it should be removed from the paper, because the paper not only absorbs the juice but imparts a peculiar taste to the meat. Always wipe the meat with a clean wet cloth before cooking; one never knows who has handled it in the store, and though it may look clean, very often it is not.

Lay the meat in a dripping pan, and sprinkle it thoroughly with salt and pepper. Put in a very hot oven and let it get seared, or browned, on both sides. This closes the outer cells and prevents the juices from escaping. Now pour about 1 pint of boiling water into the pan and baste the meat often with it. It is not necessary to put any fat in the pan, as there should be a good layer around the roast. If the meat is liked rare, allow 12 minutes roasting to the pound; if liked well done, allow 15 minutes to the pound.

Gravy.—When the meat is done, put it on a hot platter and keep it hot. Let the liquid in the pan settle, then pour the fat off and save it. Add 1 cup of boiling water to the liquid remaining in the pan, and thicken it with 2 tablespoonfuls of flour moistened with 4 tablespoonfuls of water. Season with salt and pepper, and simmer 5 minutes. If it is not perfectly smooth, strain it through a wire sieve.

Asparagus on Toast.—Wash the stalks in fresh cold water; break off the woody part. It may seem as if a good deal is wasted by thus breaking instead of cutting the ends off, but it will be found that all below the break is woody and not fit to eat. Tie in a bunch with white string, and plunge into boiling salted water. Boil vigorously for from 20 to 30 minutes, according to the size of the stalks. Toast 4 slices of stale bread; dip them very quickly into boiling water, and lay on a hot platter; then put little bits of butter on top. When the asparagus is done, lift it out of the water with two forks, to prevent its breaking, and place it on the toast. Cut and remove the strings. Pour melted butter over the asparagus and sprinkle with salt and pepper. This is by far the nicest way of preparing asparagus, though some prefer it cut in pieces about an inch long and served with a cream gravy. This is a very good way to cook it when it is a little older and tougher. In this case, cook the stalk parts first for about 10 minutes before adding the tips, as they are always tender and will cook to pieces if put in with the tougher parts and cooked the full time.

When the asparagus becomes tender, stir in 2 heaping tablespoonfuls of flour moistened to a smooth paste with 4 tablespoonfuls of cold water. Stir carefully, so as not to break the asparagus, and when it is thick add 1 tablespoonful of butter, ½ teaspoonful of salt, and a dash of pepper. Serve on squares of toast.

New Potatoes and Cream.—Wash the potatoes thoroughly and scrape with a knife or scrub with a very stiff brush. The scrubbing will almost always take off the skin, and is much quicker than scraping. Let them stand in fresh cold water for ½ hour; this makes them fresh and crisp. Be careful to remove all the little eyes and specks. Nothing looks worse than potatoes brought on the table with specks in them. Cook in boiling, salted water for 20 minutes. Drain off the water and set the saucepan on the back of the stove; cover it with a towel—not with the lid. This allows any moisture that remains to escape and still keeps the potatoes moist enough.

Cream for the Potatoes.—Melt 1 tablespoonful of butter in a small saucepan; add 1 tablespoonful of flour and mix thoroughly. Add gradually 1 cup of milk, stirring vigorously all the time to prevent lumping. When smooth, add ¼ teaspoonful of salt and a dash of pepper. Put the potatoes into the dish in which they are to be served, and pour the cream over them.

Green Peas.—If you have a garden of your own and raise your own peas, do not pick them until just before you wish to use them. Peas, as well as corn, lose their sweetness when they are allowed to lie for any length of time. If you buy them, always try to buy and use them on market day, as they are picked late the day before for the market. Shell them, and rub them lightly and quickly between the hands in a cullender; this removes all the little stems, and they will settle to the bottom of the cullender, and if it is shaken once or twice they will sift through. Cook the peas immediately in bubbling, boiling, salted water. Let them cook for 20 or 25 minutes, or until they are wrinkled. Pour off the water and add ½ cup of sweet milk, 1 tablespoonful of butter, and ¼ teaspoonful of salt. Some people like a little sugar added if the peas are not sweet enough.

Green Corn.—Use the corn as soon after it is picked as possible. Strip off the husks and pick off all the silk. If the ears are very long, break them in two. Plunge them into boiling salted water, and let them *boil* for from 10 to 15 minutes. If corn is not very young, boiling it in milk instead of water improves it, but care should be taken to prevent the milk from scorching. Remove from the water or milk, and pile on a warm platter and cover with a napkin. If there is any left after dinner, cut it off the cob and save it, as it is very nice cooked with lima beans as succotash.

Spinach.—The roots of the young spinach that is now on the market need not be cut off, as they are so small and tender that they are not disagreeable. Pick over carefully and remove all bad, wilted leaves. Wash *thoroughly* in 3 or 4 waters until all the grit is washed out. Put into a large porcelain kettle; press it down and pour on enough boiling water to cover it. Boil until tender; 20 minutes is enough. Pour it into a cullender and press the water out with a potato-masher. Chop or cut it fine and add 1 tablespoonful of butter, ½ teaspoonful of salt, and a dash of pepper. Half a peck of spinach is plenty for 5 or 6 people.

Boil 2 eggs until hard and put them in cold water to cool; break off the shell and cut them crosswise in thin slices. Put the spinach in a hot dish, smooth the top over and arrange the slices of egg on top. The white rings may be arranged around the edge and the yolks rubbed through a sieve and piled in the center. Another nice way is to add ½ cup of cream after the spinach is chopped. Then with a lard spoon beat it until it is all creamy, add 1 tablespoonful of butter, ½ teaspoonful of salt, and a dash of pepper. Serve on squares of buttered toast.

Tapioca Cream.—Wash 3 tablespoonfuls of pearl tapioca in warm water. Put 3 cups of milk into a double boiler (or a saucepan set in another pan of hot water), and when the tapioca is washed add it to the milk. Let this cook until the tapioca is about twice its original size, soft and transparent. Beat the yolks of 3 eggs until light; add 3 tablespoonfuls of granulated sugar and a pinch of salt. Pour the milk and tapioca onto the eggs, stirring all the time, and when thoroughly mixed return it to the double boiler and cook 5 minutes, stirring constantly. Beat the whites of the eggs stiff, and when the custard has cooked for five minutes pour it onto the whites. Mix well and add 1 teaspoonful of vanilla. Let it get very cold, and serve either alone or with preserved fruit.

This is a delicious dessert and is really not hard to make. It should be made in a pan with hot water under it, as it is very apt to stick to the bottom. As it has to cook some time, the milk will scorch if directly over the fire. Do not cook the tapioca in water and then add milk; this makes a very watery and poor substitute and only saves one cup of milk.

NOTICES.

THE SIXTEENTH ANNUAL CATALOGUE OF THE ROSE POLYTECHNIC INSTITUTE.—An examination of this catalogue impresses one with a favorable opinion of the institution whose work it describes. The Institute gives courses in Mechanical, Electrical, and Civil Engineering, Architecture, and Chemistry, based upon Drawing, Modern Languages, Mathematics, Mechanics, Physics, Chemistry, and Shop Practice. A particularly commendable feature of the instruction is the strong course in mathematics, and the large amount of work required in theoretical and applied mechanics; calculus is begun in the last term of the freshman year, so as to be employed in the advanced algebra of the sophomore year, and in the second term of the sophomore year a course in quaternions prepares the student to deal with the directed quantities that appear in mechanics. The work in mechanics extends continuously through the four years. The work in drawing and design is also very complete in the engineering courses, and the same may be said of the shop work. It is a little surprising that, in modern languages, 3 full years are devoted to German and only 1 to French; for the engineering student, the two languages are of almost equal importance. On the whole, the aim of the Institute is to thoroughly ground the student in the all-important principles underlying the engineering professions, rather than to waste their time on special subjects of a purely descriptive nature; this, we believe, is the correct policy.

BOOK REVIEWS.

A COURSE IN MECHANICAL DRAWING. By John S. Reid, Cornell University. Cloth, 8vo, 128 pages. 168 figures. Published by John Wiley & Sons, New York. Price, $2.00.

This book is primarily intended for class instruction in mechanical drawing in colleges, high schools, and technical schools, and presents in a concise, yet attractive, manner the essential principles of the subject. The five chapters of the book are devoted respectively to Instruments, Geometrical Drawing, Conventional Lettering and Figuring, and Orthographic Projections. The chapter on geometrical drawing contains the common geometrical constructions and a few that are not usually given in textbooks on drawing. The chapter on conventions should prove useful to draftsmen engaged in practical work. We agree with the author's statement that color tints are preferable to section lining for indicating the kind of material. In the orthographic projection, the author has followed current practice in using the third-angle system. This chapter contains a number of instructive and practical problems, and gives a thoroughly satisfactory treatment of this somewhat difficult subject. At the end are given a few examples of isometric projections and of actual working drawings. The book will doubtless be welcomed by teachers, students, and draftsmen in general.

FIRST LESSONS IN LINEAR PERSPECTIVE. By Frederic R. Honey, Ph. B. Size, 12″ x 9″; board cover. Published by Charles Scribner's Sons, New York, 1898. Price, 50 cents.

This book consists of ten lessons in elementary perspective. To quote from Mr. Honey's preface: "These lessons have been prepared for the elementary instruction of those persons who have no knowledge of geometry, which will account for the minute details accompanying the explanation of each plate. A knowledge of some of the elementary constructions of perspective is thus placed within the reach of those who cannot avail themselves of the services of a teacher."

The book is issued in a very attractive form and the ten 12″ x 9″ plates are excellently done, the student being led by easy stages from the beginning of the subject to a point where, if he goes no further, he will be in a position to make any simple perspective drawing intelligently, and be so thoroughly grounded in the principles as to be able to continue more advanced studies with comparative ease.

No beginner should be without this book.

Erratum.

June Number.—Answers to Inquiries, No. 220, line 10 from bottom, instead of "have angle of star," read "hour angle of star."

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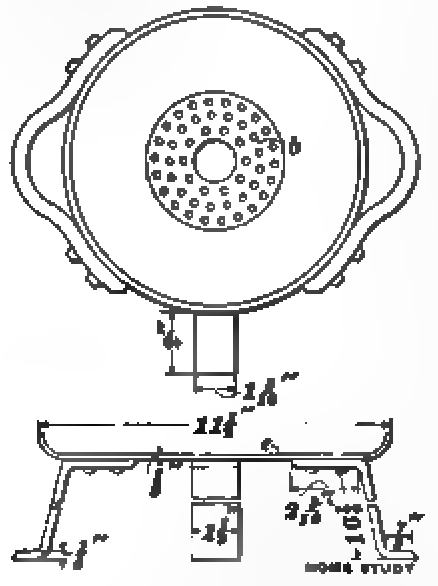
(246) (*a*) Please tell me how the Deville furnace for experimental work and melting of minerals is constructed and heated. (*b*) Please give such information as you can that would be of service to one who needs a furnace for daily use.

J. L. J., Ravenswood, L. I.

Ans. The Deville furnace is a miniature blast furnace used for obtaining high temperatures in experimental work. Such a furnace, used for determining the fusibility of fireclays, as described in a paper written by Mr. H. O. Hofman, of Boston, Mass., and read before the American Institute of Mining Engineers, is represented by the accompanying figures; *a* is a small cylindrical furnace of ⅛-inch sheet iron



lined with refractory material, open at the top and closed near the bottom by a cast-iron plate *b* having a large central opening surrounded by three rows of small perforations. Below this is the air chamber *c* with blast inlet pipe *d*. The furnace is lined for the first 5⅝ inches with a sintered magnesite which contains about 88 per cent. of magnesia, (MgO), the rest of the lining consisting of a mixture of magnesite and a kaolin containing about 38.5 per cent. of alumina (Al_2O_3) and 45.7 per cent. of silica (SiO_2). The furnace rests upon the iron plate *e*, which has an upturned edge and is supported by three legs riveted to it. The place where the furnace and plate meet is luted with a sandy, non-shrinking clay. The crucible *f*, the cover, and the support *g* are made of equal parts of calcined alumina and the same kind of kaolin as used in the lining mixed with sufficient raw kaolin to permit the whole to be properly molded. The fuel best suited for the furnace is gas carbon, as it is hard and dense, and contains a very small amount of ash. It is crushed to pass a 2-mesh sieve, and then screened on a 4-mesh sieve to remove the fines. In order to ignite the gas carbon, a small quantity of charcoal (not fine enough to pass a 2-mesh sieve) and some paper are required. The blast may be furnished by a foot-bellows, or, better, by a small fan blower, the connection between the blower and a rubber hose attached to the blast pipe of the furnace being made with a tuyere bag. A glass tube may be inserted in the rubber hose, and connected by a rubber tube with a U-shaped gauge, the pressure of the blast is regulated by tightening or loosening a clamp enclosing the tuyere bag. The clay or material to be tested is placed in the crucible, the cover put on, and the crucible placed in position upon its support. The blast is then slowly started, and the paper ignited and pressed down into the furnace with tongs, to be followed by charcoal and gas carbon. The pressure of the blast is gradually increased, and, when nearly all of the carbon has been consumed, and the crucible becomes visible (a blue glass being necessary to permit observation), the blast is shut off and the crucible removed, the support generally adhering to it. The different temperatures required can be obtained by varying the amounts of the gas carbon, and by varying the pressure of the blast.

***

(247) Will you please explain how the 133-horsepower loss by heating, as figured in the following extract from a trade catalogue, can be found without knowing the distance through which the power is transmitted? "It is well known that the *higher the pressure* the *less the loss* in transmitting a given quantity of electrical energy. The principal reason is that the loss is governed directly by the quantity of the current transmitted. The rule is that the loss by heating equals the square of the current multiplied by the total resistance of the circuit. To carry 100 amperes through a wire having 10 ohms resistance will cause a loss of 100 × 100 × 10 = 100,000 watts, which is about 133-horsepower loss from heating. If the pressure is 100 volts, the available power to be delivered is 10,000 watts, which is 90% of the total energy lost in the transmission. If the voltage is increased to 1,000, the current can be cut down to 10 amperes. The size of the wire can also be diminished to the smallest diameter that will support its own weight. The resistance will probably be increased as follows. A No. 3 wire will be needed to carry 100 amperes, and a No. 16 will carry 10 amperes, but the latter would not hold its own weight over long spans. A No. 8 would be necessary. This has a resistance of about three times that of No. 3 wire. The current of 10 amperes will, therefore, be carried through a resistance of 30 ohms. The loss will be 10 × 10 × 30 = 3,000 watts, or about 30 horsepower—a saving of over 100 horsepower."

F. S., Chattanooga, Tenn.

Ans.—As stated above, the heat loss of any electrical circuit equals the current squared multiplied by the resistance. The resistance being known, the distance of transmission does not come into account. If the resistance were not known, it would be ascertained

Note.—For conditions to be observed by subscribers wishing to have questions answered in this department, see advertising page II.

by multiplying the electrical distance by the resistance per unit length, with proper allowance for the resistance of joints and connections. Later on in the circular to which you refer, it is stated that No. 3 wire is used. Reversing the rule just stated for finding the total resistance, the distance of transmission is found to be about 5 miles, corresponding to an electrical distance of about 10 miles. It is mentioned that the heat loss is 100,000 watts, and that the output of the dynamo is 10,000 watts. As it is impossible for the line to dissipate more energy than is furnished to it, this case is obviously given as a striking example of a condition which might arise and be expected to operate successfully. The second assumption shows exactly the opposite, where the heating loss is only 1,000, or 10% of the total energy furnished, instead of the power furnished being 10% of the line loss from heating.

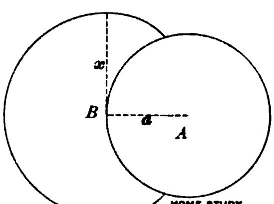
***

(248) (*a*) Please explain how the valves are set, and how many there are at the steam end of each of the following pumps: the Knowles, the Cameron, the Hughes, the Dean, the Blake, the Marsh, the Manistee, the Worthington, the Mason, and the Smith and Vaile. (*b*) Also the movement of the valve and valve rod or distance travel of each per stroke of piston. W. H., St. Louis, Mo.

ANS.—This is far too general and comprehensive a question to be answered in these columns. We advise you to write to the makers for catalogues, etc.

***

(249) In accompanying sketch, *A* represents a circular lake containing 1 acre of water. A rope is attached to a stake *B* on edge of such lake, and a horse is tied to the other end. How long must such rope be to enable the horse to feed over 1 acre of ground? SUBSCRIBER, Little River, Conn.



ANS. — Let x = length of the rope in feet, a = radius of lake in feet. It can be shown that the area grazed over is $\frac{\pi x^2}{2} + \frac{x^3}{3a}$. Solving this equation by Horner's method, we get $x = 1.2557a$. Hence, $x = 147.964$ feet.

***

(250) (*a*) Please explain the meaning of the terms "wet" and "dry" return main, as used in HOME STUDY MAGAZINE, November, 1897, article entitled "Heating Buildings from Street Mains." (*b*) What causes the resistance to be reduced on an electric circuit whenever there is a short circuit on the line? (*c*) What changes must be made to convert a dynamo into a motor? SUBSCRIBER, Cincinnati, Ohio.

ANS.—(*a*) A wet return main, as understood by the heating trade, is a return main that is constantly filled with water of condensation; it is in fact, a return main which is laid below the level of the water-line in the return risers. A wet return main is usually run on top of the cellar floor. When a building is heated with "district steam," the wet return main is run below the level of the steam-trap, and when a steam boiler is used the wet return main is run below the boiler water-line. A dry return main is simply a return main which is run high enough to be clear of water—run, in fact, above the level of the steam trap or the boiler water-line, as the case may be. It is called "dry" because it becomes filled with steam; the water of condensation runs along the bottom of the pipe. (*b*) A short circuit is essentially due to placing some conductor across electric mains having considerable difference of potential between them. The low resistance of the bridge causes an excessive current to flow, this being known as a "short circuit." Since this bridge conducts the current from one main to the other, by a path of lower resistance than that afforded by the lamps or other receptive devices, the resistance of the circuit as a whole becomes low. (*c*) A dynamo becomes a motor by merely supplying current to it at the voltage which it would itself give when running as a dynamo at the required speed.

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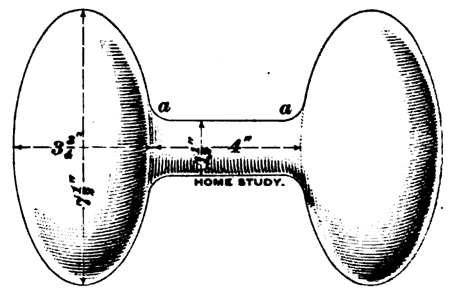
(251) (*a*) What should be the dimensions of a 30-pound dumb-bell? (*b*) How is the volume of a sphere calculated? H. M., Deadwood, S. D.

ANS.—(*a*) A cast-iron dumb-bell made according to the dimensions in the accompanying figure will weigh about 30 pounds. If the bar is 1½ inches in diameter



and 4 inches long, its weight—on the assumption that 1 cubic inch of cast iron weighs 0.26 pound—is figured in the following manner: $4 \times 1.5^2 \times .7854 \times .26 = 1.84$ pounds, nearly, say 2 pounds, allowing for the fillets at *a*, *a*. We then have 28 pounds to divide between the ends—14 pounds to each end. These ends are ellipsoidal in form. The weight of a 7½″ × 3¾″ ellipsoid is $.5231 \times 7.5 \times 3.75^2 \times .26 = 14$ pounds, nearly. Make the pattern according to these dimensions: Weigh the pattern (which should be of well dried pine), and its weight multiplied by 16 should equal 30 pounds. (*b*) The volume of a sphere $= 0.5236d^3$, where d is the diameter of the sphere.

***

(252) (*a*) Can gunpowder or any other explosive of like nature be used in cylinders to move pistons, and, if so, why is it not thus used? (*b*) If it can be used, what weight of gunpowder would be sufficient to develop ½ horsepower for 4 hours? (*c*) Do you think gunpowder will ever be used as a motive power? (*d*) Do you know of any book on the subject? S. T., Houston, Texas.

ANS.—Gunpowder cannot be used as a motive power, because it acts too quickly. It takes time to put a body in motion, as you can readily ascertain for yourself by trying to move a heavy body. The action of gunpowder being practically instantaneous, the pressure developed is enormous; hence, after the explosion, one of three things must happen: (1) the piston will be blown out of the cylinder; (2) the cylinder will burst; (3) the cylinder-head cover will be blown off.

***

(253) I wish to use a settling tank similar to that described in your March number to purify water for our boiler. Carbonate of lime is the impurity. I desire to build an open tank to hold 1,500 gallons of water, the tank to be filled and the soda added every morning, and the impurities settled so that the water can be used in the boiler at night, say 10 or 12 hours after treating the water. (*a*) Would that time be sufficient for all the lime to settle if cold water is used? (*b*) How much caustic soda should be used

for the 1,500 gallons of water? The water is quite strongly impregnated with the carbonate of lime, but I cannot say just how much.

F. L. W., Traer, Iowa.

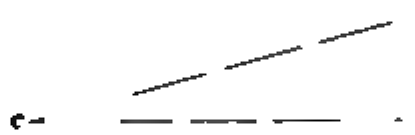
ANS.—(a) Yes; we think that the time you mention will be sufficient. (b) First try about 70 grains of soda ash per gallon. You will find out, as you go along, whether this is a suitable quantity. If you use too much in proportion to the impurity of the water, your boiler will foam and cause trouble.

***

(254) We enclose a blueprint showing method of laying out the profile of a cutter for cutting the space between the teeth of a helical gear. The print explains itself. Is our method right? If not, what is the correct way of making the layout?

B. O. H., Ansonia, Conn.

ANS.—In the drawing you sent us—we have not reproduced it—the angle marked *angle of helix* is not drawn according to the foot note. However, the accompanying figure shows the correct construction. After making an exact layout of the adjacent faces of two adjacent teeth, draw the center line ca, and the limiting lines wx and yz of the tooth face. Draw ob, making the angle boa as desired. From the point d, where ob cuts yz, draw de, cutting the pitch circle P_1 in e. Draw ce, cutting the addendum circle A_1 in f and the root circle R_1 in g. Draw fh and gi, also oh



and oi. Project j, k, l, m, n, and p to j', k', etc. Draw $j'j''$ and $p'p''$ parallel to the center line oh, $k'k''$ and $n'n''$ parallel to od, and $l'l''$ and $m'm''$ parallel to oi. Produce all these lines to the left of wx, and with o as the center describe circles tangent to the three pairs of parallel lines, as shown. The diameters of these circles are the diameters of the cutter at qq', rr', and ss'. If, for the sake of greater accuracy, intermediate diameters are desired, draw any required number of intermediate circles I_1, and proceed with them as above. In this way the curve qrs can be accurately laid out. It must not be forgotten that ss' is straight.

***

(255) (a) I have sent some small rocks for examination; they are marked and numbered. Please tell me what kind of rocks they are and what metals they contain. (b) What are the dark spots in Nos. 5, 6, 7, 8, and the green in No. 10. Have 0 and 1 any market value?

J. L. McL., San Marcos, Texas.

ANS.—(a) 0. Quartz (crystalline). Under this is chalcedony, or agate, a variety of quartz (non-crystalline). 1. Same as 0. Quartz crystals are stained by iron oxide. 2. Quartz pebbles. 3. Milky quartz. 4. Red is jaspar. Black is chert, a variety of flint stained by iron. 5. Trachyte. 6. Phonolite, a variety of trachyte, may contain gold. Not visible, however. 7. Quartz porphyry. May contain gold. Not visible, however. 8. Sandstone stained by iron. Has been burned. 9. Altered rhyolite. May contain gold. Not visible, however. 10. Calcite (carbonate of lime). Red stain is iron oxide. Green stain may be carbonate of copper, or possibly organic matter. Hardly enough to tell. (b) Dark spots in 5 and 6 are due to a ferromagnesian metal, the exact nature of which it is impossible to state. In 8 are due to iron, same as red. 0 and 1 have no market value.

***

(256) (a) What size of vertical-tubular boiler with water firebox and 1-inch iron tubes would be required to run a boat 21' x 5', size of engine 3" x 3", with natural draft? Please give thickness of plates and the number of 1-inch tubes, to stand a steam pressure of 150 or 200 pounds per square inch. (b) Would a compound engine be any advantage for so small a boat? If so please give size of low-pressure cylinder to go with a 3" x 3" high-pressure cylinder. (c) Please give a rough sketch of air pump suitable for the 3" x 3" engine.

A. P. F., Augusta, Me.

ANS.—(a) Your question does not contain sufficient data on which to base a satisfactory answer. If you will tell us the number of revolutions you intend the engine to make, and, if possible, where you want cut-off to take place in the high-pressure cylinder, we could answer your question. It is necessary to be in possession of these data in order to compute the steam consumption, which, of course, determines the boiler capacity. (b) Nothing is gained by compounding so small an engine, unless you are going to run in salt water, in which case you might do so, putting in a keel condenser. The low-pressure cylinder ought, for the high pressure you propose to use, to be at least 6¼ inches in diameter. (c) The design of the air pump depends upon the data you omitted. It is also necessary to know whether the pump is to be single- or double-acting, direct-connected or independent, for surface or jet condenser.

***

(257) (a) How would you proceed to find the striking point on an engine? (b) How would you proceed to set the valves of a pump? (c) Can you give me any definite instructions for setting the valves of a Corliss engine?

G. M. R., Lo Lo, Montana.

ANS.—(a) What do you allude to as the striking point? Do you mean that you want to determine at what point, if the strike were prolonged, the piston would strike the cylinder head; in other words, to determine what clearance your pistons have? If so, you will have to uncouple your main rod at the front end. First, however move the engine slowly over the dead centers, and scribe a line on the guide at the front and back end, marking the extreme positions of the crosshead wings. Then uncouple and bump up at each end, and again mark where the crosshead goes to. The space between these marks will give you the clearance at each end. Whether or not you should give the same clearance at both ends

depends on the design of your main rod. (*b*) This question is too indefinite. There are many kinds of pumps. (*c*) See HOME STUDY MAGAZINE, May, 1898, Answers to Inquiries, No. 185.

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(258) I enclose a sketch, Fig. 1, of a water-tube boiler that I am developing, and about which I wish to ask a few questions. The boiler consists of two sections; and, except where they are connected by the water tubes, these sections are entirely separate. As indicated on the sketch, one section contains water, and the other, steam only. (*a*) Would such a boiler be safe? (*b*) If a 2-inch tube be flattened until the walls are but ¼ inch apart inside, will it make steam faster than a 2-inch tube of circular section? (*c*) In my boiler, the tubes are flattened as shown in Fig. 2, and are arranged one above another, and set at an angle. Can you suggest a better arrangement of flattened tubes? (*d*) What I want to get is a perfectly safe boiler having large water space and the ability to make dry steam rapidly. Do you think I have obtained all this? (*e*) Can I with safety flatten the 2-inch tubes to ¼ inch inside the walls? Fig. 2 does not show the correct spacing of the tubes; they should be as near together as possible.
H. C. B., Bangor, Me.

ANS.—The sketch of your proposed boiler presents an impossibility. You cannot have steam only in

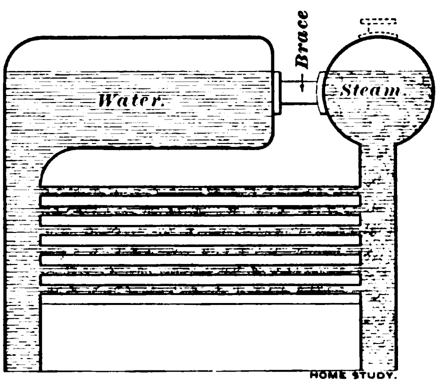

FIG. 1.

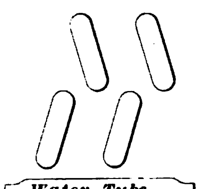

FIG. 2.

one section and water in the other. Before firing up, you will have water in both, and after heat is applied steam will accumulate in both. If you now take steam from the section marked "Steam," the pressure there will decrease and water be pressed from the section marked "Water" through the tubes into the "Steam" section. (*a*) This arrangement even thus is absolutely *unsafe*, as the thin sheets of water contained in the tubes would quickly evaporate; and, the steam being obliged to press through a high column of water on both sides, would certainly dangerously affect the strength of the tubes. You neglect the first principle of a boiler, viz., the *circulation of water*. If you remove the "brace," and make a connection there, you will have some circulation, and have a boiler somewhat similar in fundamental principle to the Heine safety boiler. (*b*) The flatter the tube, the thinner the sheet of water, and the faster the evaporation evidently, but the faster also the flow of the circulating water through the tube, and, finally, the shorter the time given for evaporation. Besides, flat tubes are bad to make and are weaker than circular ones. There is nothing or almost nothing gained then by flattening the tubes. (*c*) The arrangement of the location of the tubes in zigzag position is correct enough. (*d*) and (*e*) are answered by the above.

***

(259) (*a*) What is the best way to pan wash gold? (*b*) What are the best pans to use?
J. B., Fredericksburg, Va.

ANS.—(*a*) and (*b*) Gold is washed from gravel deposits on a small scale by means of pans. The pan used is 18 to 20 inches wide at the top, 8 to 12 inches wide at the bottom, and 2½ to 3 inches deep: it is made by pressing out a single sheet of Russia iron. In order to stiffen the edge, it is turned over on iron wire. The pan is used as follows: It is filled to about two-thirds of its capacity with gravel (or crushed ore), which is next thoroughly mixed with water, by placing the pan and contents in a quiet, shallow stream, or a pool of water, and stirring the mixture with the hand to break up lumps of dirt and free the gold. The pan is now taken in both hands a little behind its diameter, inclined slightly away from the operator, and the upper edge raised above the surface of the water, leaving only the lower edge submerged. In this position the pan is shaken from side to side, while a slight gyratory, circular movement is also imparted to it. The water disengages all the light earthy particles and carries them away. The large pebbles are picked out, and, after being washed to remove any particles of gold that may adhere to them, are thrown away. The washing is continued, using plenty of clear water, until nothing but the gold, black sand, and other heavy minerals remain in the pan; it is then lifted out of the water and almost all of the water poured off, and by a dexterous movement of the wrist, something like that used in vanning, the fine material is caused to pass around the lower edge of the pan with the water, in a "string." The "colors" (yellow specks of gold) are to be seen at one end of the string, and also occur for the first inch or so mixed with black sand, while the quartz sand forms the light end of the string and is washed off, or carefully scraped away with the finger or thumb. The black sand, when magnetic, is separated from the gold by a magnet, or by drying and blowing away, the latter being a very crude and sometimes wasteful process. The gold may be amalgamated by introducing a small quantity of mercury into the pan; the liquid amalgam being easily separated from the sand. The excess of mercury is removed by straining through a piece of buckskin, and the rest of the mercury driven off by heat.

***

(260) (*a*) What is the value of porphyry as a building stone, as compared with granite and marble? (*b*) If it could be supplied at the cost of the latter, do you think it would have the preference? (*c*) From what parts of this country is it generally obtained? I happen to know of the location of a large quantity in one of our southern states, and I have thought that it might have a superior commercial value.
J. T. S., Saginaw, Mich.

ANS.—(*a*) Porphyry is a more expensive material than either granite or ordinary marble; but the name has come to be applied to many inferior materials differing so widely in composition that the name is no longer distinctive. For instance, the porphyry which comes from Cornwall, England, is itself a form of granite. (*b*) Its selection in any case would depend on such circumstances as strength, structure, and color, and would probably be given a preference over granite on account of its greater beauty, if it could be worked at no greater cost; at present, however, such is not the case. (*c*) Maine, Massachusetts, New Hampshire, Pennsylvania, Missouri, and several other states possess large quarries of this material

which have not been developed on account of the great expense of working.

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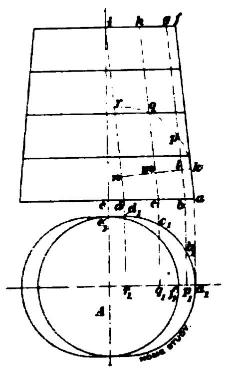
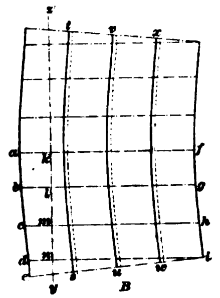
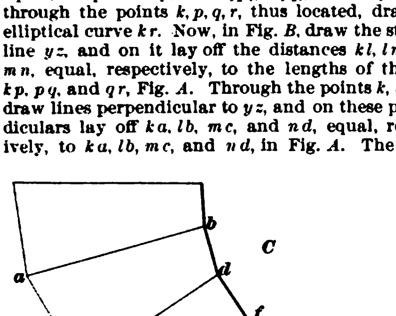
(261) Kindly give me the developments of the enclosed shapes. J. V. H., Bridgeport, Conn.

ANS.—The development of the first shape is shown in Figs. *A* and *B*. First, divide the quarter circle $a_1 d_1$, which is part of the plan of the base of the figure, into any number of parts. In the figure, three parts have been chosen, the points of division being b_1, c_1, d_1. Project these points to b, c, d in the elevation, and draw bg, ch, and di parallel to af. At any

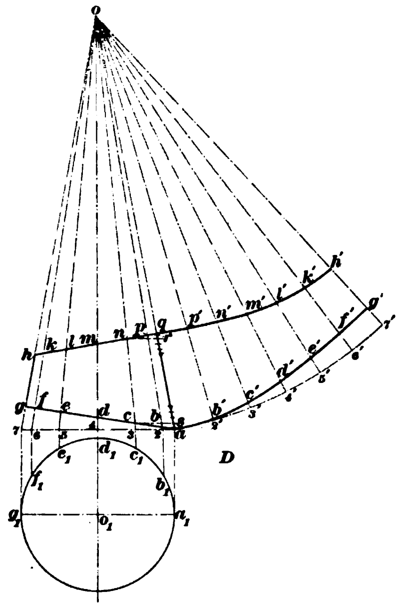




convenient point draw line kn perpendicular to af. From this line lay off the distances lp, mq, and nr, equal, respectively, to $b_1 p_1$, $c_1 q_1$, and $d_1 r_1$, and through the points k, p, q, r, thus located, draw the elliptical curve kr. Now, in Fig. *B*, draw the straight line yz, and on it lay off the distances kl, lm, and mn, equal, respectively, to the lengths of the arcs kp, pq, and qr, Fig. *A*. Through the points k, l, m, n, draw lines perpendicular to yz, and on these perpendiculars lay off ka, lb, mc, and nd, equal, respectively, to ka, lb, mc, and nd, in Fig. *A*. The points



a, b, c, d locate one edge of the sheet. From a, b, c, d, lay off af, bg, ch, and di, each equal to fa, Fig. *A*; these points locate the development of the upper edge. On di, Fig. *B*, lay off the triangle dei, equal to the triangle dei, Fig. *A*; then, $afie$ is the development of one-fourth of the shape. To divide it into the four sheets of which it is to be formed, divide each of the lines af, bg, etc. into four parts, and through the points of division draw the lines st, uv, and wx, allowing for lap, as shown by dotted lines. The elbow, Fig. *C*, may be developed by assuming that each section is a part of a cone. Making this assumption, the development of the middle section is shown in Fig. *D*. Prolong the sides aq and gh to meet at o, bisect angle o, and draw the axis oo of the cone; through a draw $a7$ perpendicular to oo_1. With o as a center, and oa as a radius, draw circular arc $a7'$; also, draw semicircle $a_1 d_1 g_1$, the plan of the base of the cone; divide it into six parts, and project the points of division b_1, c_1, etc. to $2, 3, 4, 5$, etc. Upon the arc $a7'$, lay off the distances $a2'$, $2'3'$, etc., equal to the arcs $a_1 b_1$, $b_1 c_1$, etc. Now, through o draw the lines $o2$, $o3$, $o4$, etc., and the lines $o2'$, $o3'$, $o4'$, etc., the former lines giving the points c, d, e, l, m, etc.



Now, take any line, as $nc3$, and project the ends n and c horizontally upon aq, as at r and s. From $3'$ lay off $3'c'$ and $3'n'$, equal, respectively, to as and ar. Proceed in the same manner with pb, md, le, kf, and hg, and the points p', m', l', b', d', e', thus obtained, will be the edge of the developed sheet. In order that this method of development may give good results, some care must be exercised in choosing the lines ab, cd, ef, etc., in Fig. *C*. Suppose ac and bd, Fig. *C*, to be prolonged until they meet, and let the angle between them be bisected. Suppose also that ce and df are likewise prolonged, and the angle between them is bisected, then cd should make nearly equal angles with these two bisectors.

***

(262) I have a 20-horsepower, double-cylinder, cross-compound traction engine, and I wish to purchase a sawmill and to run it by this engine. The pulley on the engine is 48 inches in diameter; that on the sawmill is 20 inches in diameter. The diameter of the lower saw is 60 inches, and the upper one 30 inches. (*a*) Will the engine be suitable? (*b*) Is the sawmill too large to be successfully operated by the 20-horsepower engine? If so, what size of mill would you recommend to be run by this engine?

B. C., Cleves, Ohio.

ANS.—(*a*) By traction engine we suppose you mean a portable engine and boiler mounted upon wheels. This engine and boiler, if in good condition, could probably, with some few changes, be adapted to fill the requirements of a prime mover to run a sawmill. (*b*) Upon referring to a catalogue issued by the Standard Sawmill Machinery Co., Erie, Pa., we find, according to their specification of No. 3 sawmill, which has a main driving pulley 28 inches in diameter,

that the distance between the top-saw arbor and the main arbor is 49 inches, when apart their full limit. Hence the mill will conveniently accommodate a 60-inch lower and a 30-inch top saw. This mill, according to the catalogue, requires from 35 to 50 horsepower; the 20-horsepower engine would, therefore, be far too small to generate the power required to run a mill of this size working under usual conditions. The same concern specifies a No. 1½ sawmill, which carries up to a 60-inch saw, and is supplied with a top-saw attachment similar to that on No. 3. The main pulley on this mill is 22 inches in diameter, the capacity of the mill being from 10,000 to 20,000 feet of lumber per day. This mill requires an engine and boiler of from 20 to 30 horsepower, and would be more suitable to couple to the engine you propose to use.

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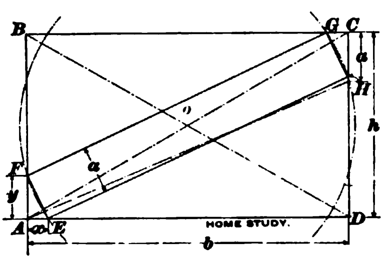
(263) I should be pleased to have you give a solution of the following problem: Given any rectangle, to construct another rectangle of a given width, such that its length shall be the greatest possible, and its general direction coincide as nearly as possible with the diagonal of the rectangle, the four corners of the required rectangle to lie in the four sides of the given rectangle. E. D. S., Ithaca, N. Y.

ANS.—The width of the required inscribed rectangle fully determines both its length and its general direction, so that no restrictions on either of these can properly be made part of the condition of the problem. To realize this, draw the two diagonals AC and BD as in the figure, so as to get the center o of the rectangle. About o describe any circle intersecting the four sides of the rectangle, and draw the lines EF, FG, GH, and HE, as shown. These lines evi-



dently form a rectangle, and it is readily seen that we could not change the length EH of the same, without at the same time changing its width EF, as both of these lines will change if we change the radius of the circle. Designating the distance AF by y, the distance AE by x, the base of the given rectangle by b, its altitude by h, and the width of the required rectangle by a, we may write:

$$y^2 + x^2 = a^2, \qquad (1)$$

as the triangle AEF is right-angled, and

$$\frac{x}{y} = \frac{h-y}{b-x}, \qquad (2)$$

as the triangles AEF and DHE are similar. Eliminating between these two equations leads to a biquadratic equation, so that we might just as well solve any particular example tentatively, by means of the two equations as they stand. Referring again to the figure, it will be seen that $\frac{x}{y}$ must be less than $\frac{h}{b}$ and greater than $\frac{h-a}{b}$, and also that it must be more nearly equal to this latter expression. We then write $\frac{x}{y} < \frac{h}{b}$, $x^2 < \frac{h^2}{b^2}y^2$, which compared with equation (1) gives

$$a^2 - y^2 < \frac{h^2}{b^2}y^2,\ a^2 < y^2\frac{h^2+b^2}{b^2},\ y > \frac{ab}{\sqrt{h^2+b^2}}. \qquad (3)$$

Similarly, $\frac{x}{y} > \frac{h-a}{b}$, $x^2 = \frac{(h-a)^2}{b^2}y^2$, which compared with equation (1) gives

$$a^2 - y^2 > \frac{(h-a)^2}{b^2}y^2,\ \ a^2 > \frac{(h-a)^2+b^2}{b^2}y^2,$$

$$y < \frac{ab}{\sqrt{(h-a)^2+b^2}}. \qquad (4)$$

By means of (3) and (4) we thus readily locate the value of y between two limits. *Example:* Suppose that in a certain case $b = 18$, $h = 10$, and that the width a of the required inscribed rectangle is to be 3. From (3) we then get: $y > \frac{3 \times 18}{\sqrt{10^2 + 18^2}} > \frac{54}{20.59} > 2.622$: and from (4), $y < \frac{3 \times 18}{\sqrt{(10-3)^2 + 18^2}} < \frac{54}{19.313} < 2.796$. y must thus be greater than 2.622 and less than 2.796, but more nearly equal to the latter figure. It must accordingly also be greater than the mean of these figures, which is $\frac{2.622 + 2.796}{2} = 2.709$. Let us try $y = 2.75$. From (1) we then get $x = \sqrt{a^2 - y^2} = \sqrt{3^2 - 2.75^2} = 1.199$. $\frac{x}{y}$ becomes $\frac{1.199}{2.75} = .436$. $\frac{h-y}{b-x}$ becomes $\frac{10-2.75}{18-1.199} = \frac{7.25}{16.801} = .4315$. As according to (2) $\frac{x}{y}$ should equal $\frac{h-y}{b-x}$, this shows that y has been taken too low. Trying $y = 2.76$ we get $x = \sqrt{3^2 - 2.76^2} = 1.176$. $\frac{x}{y}$ then becomes $\frac{1.176}{2.76} = .426$, and $\frac{h-y}{b-x}$ becomes $\frac{10-2.76}{18-1.176} = .43$. These results show that 2.76 is too *great* a value for y. Taking, now, the mean of $x = 1.199$ and $x = 1.176$, we get $x = 1.1875$; and the mean of $y = 2.75$ and $y = 2.76$, we get $y = 2.755$, which values are found to satisfy equations (1) and (2) quite closely.

***

(264) We have considerable trouble in raising steam to supply the engine of our mill and kiln. The boiler is tubular, 48 inches by 14 feet, fifty 3-inch flues. The smokestack is 22 inches in diameter, and 50 feet in height. The boiler setting is considered good. We have a steam jet in the stack to increase the draft, and have also a blower which blows air under the grate, but this does not seem to help much. In the daytime we burn sawdust; at night we burn wood. The soot in the flues is scraped and blown out every night. Will a larger smokestack help? If so, what dimensions should it have? Our engine is 11″ x 16″, and makes 200 revolutions per minute. Would it save much steam if we reduced the speed to 140 revolutions per minute, and enlarged the driving pulley so as to get the same belt speed at the line shaft? The power used is from 30 to 35 horsepower. J. A., Frances, Wash.

ANS.—The diameter of your stack seems to be well suited to the general dimensions given for the boiler. The strength of the draft could be increased by making the stack higher—an increase of 25 feet would add very considerably to the draft and might be sufficient to make up for the present lack of steam. It is possible the grates are not well suited for the fuel you are using, or that the grate area is too small. In regard to the engine, the load seems to be rather small, and it is possible there might be a small increase in economy by the change in speed you suggest; this, however, depends considerably on the type of the engine and the kind of work it is doing. If you are using live steam to heat your kiln, you could save considerable by arranging your piping so as to use the exhaust steam from the engine while it is running.

(265) (*a*) I show in Fig. 1 a section of an apparatus that I wish to have explained: *a* is a cylinder of wood with a hole through the center; one end is cup-shaped, to receive a ball that fits it; the other end is a mouthpiece. If I place the ball against the cup-shaped end and blow through the hole in the cylinder, the ball will not fall off, no matter what position I hold it in; but as soon as I stop blowing, the ball falls. (*b*) What is the Cartesian diver?

J. T., Dallas, Texas.

a

FIG. 1.

ANS.—(*a*) Try the following experiment: Take an empty spool and blow through it at a piece of paper. You will find that the paper will stick to the spool. The explanation is exceedingly simple. The current passing through the bore *c*, (Fig. 2,) is deflected until, from the center and around the face of the spool, the air flows rapidly in a direction parallel to the surface of the paper. Now, under normal conditions, the atmosphere presses equally on both sides of the paper; but, when a stratum of air on the upper side is caused to move rapidly in the direction indicated, the active pressure on this side, represented by the arrows *a*, is reduced, while the pressure on the under side remains unaffected. A condition ensues where the difference between the pressures *a* and *b* is greater than the force with which the air in the bore *c* endeavors to blow the paper away. When this point is reached—dependent upon the size of the piece of paper and its proximity to the spool—the paper sticks to the spool, and the harder you blow, the more securely it hugs the spool. This reasoning will enable you to understand the toy in Fig. 1. (*b*) You will find a full explanation, with illustration of the Cartesian diver, in HOME STUDY MAGAZINE, July, 1897, Answers to Inquiries, No. 250.

FIG. 2.

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(266) (*a*) What is the difference between Mushet's self-hardening steel and ordinary tool steel, that their characteristics are so different? (*b*) Is Mushet's steel forged at the same temperature as ordinary tool steel, and how should metal-cutting tools made of it be hardened and their temper drawn? (*c*) Can Mushet's steel be annealed? (*d*) Cannot tools made of it be subjected, while cutting, to a degree of heat that would ruin tools made of ordinary steel, and how high is this temperature? (*e*) Can you refer me to any books or articles on this subject?

J. W. H., Attleboro, Mass.

ANS.—(*a*) Mushet's self-hardening steel contains a certain percentage of tungsten. It is very difficult to forge Mushet's steel, the forging must be done at as low a temperature as possible. Metal-cutting tools are hardened by allowing the tool to cool very slowly after forging. (*c*) No. (*d*) This is a question that we are not prepared to answer. Mushet's steel is better than cast steel for working in cast iron. The writer prefers a good cast-steel (like Sanderson's or Jessup's) tool for working in other metals. (*e*) There is not much literature on the subject. Howe's "Metallurgy of Steel" (Price $10.00) describes the manufacture of steel in all its branches; we doubt, however, whether it contains the information you want.

***

(267) Show by trigonometry that a triangle is determined when the area, an angle, and the side opposite that angle are given.

S. C., San Francisco, Cal.

ANS.—Suppose the side AB and the angle ACB to be given, and let S denote the area of the triangle.

Then, $$ab = \frac{2S}{\sin C},$$

and $$c^2 = a^2 + b^2 - 2ab\cos C;$$

therefore, $$a^2 + b^2 = c^2 + \frac{4S\cos C}{\sin C}.$$

Hence,

$$(a+b)^2 = c^2 + \frac{4S(\cos C + 1)}{\sin C} = c^2 + 4S\cot\frac{C}{2}.$$

In like manner, $(a-b)^2 = c^2 - 4S\tan\frac{C}{2}$.

Thus, $$a + b = \sqrt{c^2 + 4S\cot\frac{C}{2}},$$

$$a - b = \sqrt{c^2 - 4S\tan\frac{C}{2}};$$

therefore,

$$a = \frac{1}{2}\left(\sqrt{c^2 + 4S\cot\frac{C}{2}} + \sqrt{c^2 - 4S\tan\frac{C}{2}}\right),$$

and $$b = \frac{1}{2}\left(\sqrt{c^2 + 4S\cot\frac{C}{2}} - \sqrt{c^2 - 4S\tan\frac{C}{2}}\right).$$

This solution is purely trigonometrical, but the problem is easier of solution by geometry.

***

(268) I wish the following information regarding hydraulic jacks: (*a*) What is the diameter of cylinder required for a 20-ton jack to raise the load 1 foot per minute? (*b*) What is the relation of the cylinder diameter to the diameter of the pump cylinder? (*c*) What should be the length of stroke of the pump plunger, and the number of strokes required to raise a 20-ton jack 1 foot per minute?

J. B. C., Philadelphia, Pa.

ANS.—(*a*) The diameter of the cylinder depends on the pressure of the water in the cylinder, and not on the speed with which the load is to be lifted. We will assume a water pressure of 3,500 pounds per square inch, and a frictional loss in the stuffingbox or packing of the ram of 5 per cent. of the net load. The net load is $2{,}240 \times 20 = 44{,}800$ pounds, hence, the force that must be exerted, including friction, is $44{,}800 \times 1.05 = 47{,}040$ pounds. The area of the ram to exert this force with a pressure of 3,500 pounds per square inch is $47{,}040 \div 3{,}500 = 13.44$ square inches, and its diameter is $D = \sqrt{\frac{13.44}{.7854}} = 4\frac{1}{8}$ inches, nearly. (*b*) The usual diameter of pump plunger for a jack worked by hand is from $\frac{3}{4}$ to $\frac{7}{8}$ inch, and the stroke is $1\frac{1}{2}$ or 2 inches. It would be impossible, however, to raise a load of 20 tons 1 foot per minute with such a jack, since the power required would be much greater than could be exerted by a man. The speed with which one man could lift a load of 20 tons would probably be not more than $2\frac{1}{2}$ inches per minute.

(*c*) The proportions of the pump plunger will depend entirely on the manner in which it is driven. As stated in the answer to (*b*), it would be impossible to lift a load of 20 tons 1 foot per minute with a one-man hand-power jack, no matter what the proportions of the ram and pump plunger might be.

***

(269) (*a*) I wish to transmit 6 horsepower from a shaft running at 300 revolutions per minute by means of a gear of 8 diametral pitch, 8 inches in diameter. What will be the required width of face? (*b*) If 6 diametral pitch is used, what will be the required width of face? H. B. B., Chicago, Ill.

ANS. If 8 diametral pitch is used, the width of face should be 5 inches; if 6 diametral pitch, 4 inches. These dimensions are based on the assumption that cast iron is used, with an allowable fiber stress of 3,000 pounds per square inch.

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(270) I have several articles of malleable iron, highly polished, on which I desire to get a dull-black color which will be permanent and not wear off. I have tried several receipts found in books, but without success. Can you inform me how to proceed? C. E. T., Plattsburg, N. Y.

ANS.—Make the following four solutions (1) Chloride of mercury and sal ammoniac; (2) Perchloride of iron, sulphate of copper, nitric acid, alcohol, and water; (3) Perchloride and protochloride of iron, alcohol, and water; (4) A weak solution of sulphide of potassium. Apply each of these solutions successively, and let the one dry thoroughly before applying the next. Apply (3) twice and also put the articles in a bath of boiling water after applying (3) and (4). The exact shade required can be fixed by vigorous rubbing with a woolen pad moistened with a little oil. The perchloride of iron and sulphate of copper in (2) should be used in a solution of only moderate strength.

***

(271) (*a*) What angle does $\frac{1}{16}$ of an inch subtend at a distance of 1,000 feet? (*b*) What is meant by refraction of light? I. S., Osnaburg, Ohio.

ANS.—(*a*) In Fig. 1, let $oc = 1{,}000$ feet, and let aob be the required angle, ab being $\frac{1}{16}$ of an inch. The angle is exaggerated here for the sake of clearness; it is in reality so small that ao, oc, and ob may be

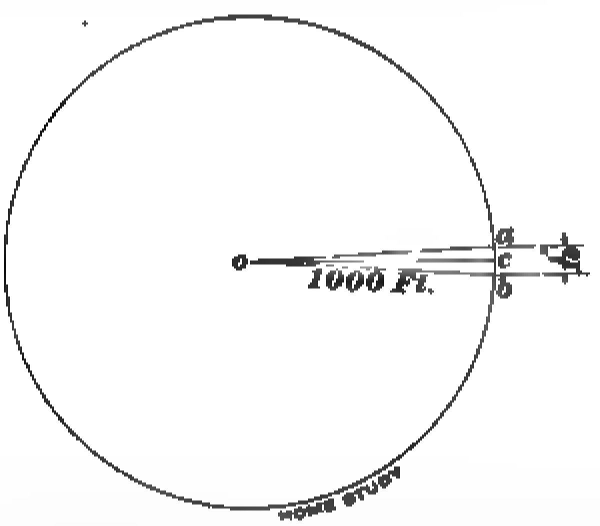

FIG. 1

considered of equal length. The length of the circumference of the circle whose radius is 1,000 feet = $2{,}000 \times 3.1416 = 6{,}283.2$ feet, and $\frac{1}{16}$ of an inch is contained in 6,283.2 feet 1,206,374.4 times; 360 degrees divided by $1{,}206{,}374.4 = .000298$ degree; this, then, is the angle subtended by $\frac{1}{16}$ of an inch at a distance of 1,000 feet. (*b*) Let ab, in Fig. 2, be a sunbeam entering a darkened room through a small hole at a, and falling at b, upon the surface of some water contained in a glass vessel. It will be found that as the beam of light enters the water, it will be bent sharply downwards in the direction bc. This bending is called *refraction*. When a ray of light passes through any transparent medium, and falls obliquely upon any transparent or semitransparent interposed body, the interposed body becomes a medium for the

FIG. 2.

transmission of some portion of the light, and this light as it enters the new medium is always refracted. A simple example of refraction is the apparent bending of a straight stick when it is partly and obliquely immersed in water.

***

(272) (*a*) Kindly publish a receipt for making copying ink for use with a hectograph. (*b*) What is the meaning of "rendering in sepia"? B. L. D., Clarkesburg, W. Va.

ANS.—(*a*) Dissolve 1 ounce of anilin violet or blue (2 R B to 3 B) in 7 fluid ounces of hot water. When cool, add to it 1 ounce of wine spirit with 4 ounces of glycerin, together with a few drops of ether and a drop of carbolic acid. Keep the ink in a well stoppered bottle. A black ink may be made by mixing together

Nigrosine black	1 part.
Water	14 parts.
Glycerin	4 parts.

If it does not copy well, add more glycerin. (*b*) The phrase is used to express the fact that sepia is the color or pigment used to produce a certain picture or illustration. If an illustration is executed with pen and ink, it is spoken of as a "pen-and-ink rendering." So, also, when sepia is used, it is called a "sepia rendering," or a "rendering in sepia."

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(273) I have charge of a 220-volt power plant situated about 1 mile from my home; I would like to have 5 electric lights in the house. (*a*) Would it be practicable to run the lights with a storage battery by taking it to the station once a week for recharging? (*b*) What would such a battery cost? (*c*) How would I have to connect it up for charging? S. S. Y., Patton, Pa.

ANS. (*a*) Yes. The largest size of portable battery No. 509 E 7, made by the Chloride Accumulator Company, Philadelphia, weighs complete 182 pounds. It will furnish 120 ampere hours at 8 volts; that is, supposing the discharge efficiency to be the same at any rate of discharge, it will furnish 120 amperes for 1 hour, or it will supply 1 ampere for 120 hours, after being fully charged with about 135 ampere hours. This battery, then, will run five 6-candlepower miniature incandescent lamps for about 14 hours, or 2 hours each evening of the week. (*b*) The retail cost of the

battery complete is \$60. (c) To charge the battery, its positive terminals should be connected to the positive bus, and the negative terminal of the battery is connected to the negative bus through a resistance that will allow only 15 amperes to pass.

***

(274) (a) I am unable to solve the following:

$$x^2 + y = 7. \qquad (1)$$
$$x + y^2 = 11. \qquad (2)$$

It is easy for me to *observe* the answer, but I cannot solve the problem mathematically. Please help me out. (b) Can you give, in your cooking department, directions for canning vegetables, such as peas, string beans, lima beans, and corn?

F. O. E., Cortland, Ohio.

ANS.—(a) From (1), $y = 7 - x^2$; whence, $y^2 = 49 - 14x^2 + x^4$. Substituting in (2), transposing absolute term, and arranging terms, $x^4 - 14x^2 + x + 38 = 0$. Now, if this equation has a real integral root, it must be a factor of the absolute term. The only numbers which multiplied together will give a product of 38 are 1×38 and 2×19. Neither $x + 1$ nor $x - 1$ will divide the equation; hence, neither -1 nor $+1$ is a root. $x + 2$ will not divide it, but $x - 2$ will divide it, the quotient being $x^3 + 2x^2 - 10x - 19$; therefore, $x^4 - 14x^2 + x + 38 = (x^3 + 2x^2 - 10x - 19)(x - 2) = 0$; whence, $x - 2 = 0$, or $x = 2$. Substituting in (1), $2^2 + y = 7$; whence, $y = 3$. Substituting both values in (2) to see if equation (2) will be satisfied, $2 + 3^2 = 11$, which is true. Therefore, $x = 2$ and $y = 3$. (b) You will find a brief article entitled "The Canning of Vegetables" in another part of this issue.

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(275) (a) Referring to Fig. 1: Having given the radius and length in degrees of the arc abc, how is the length of the chord adc and the height bd determined? (b) Referring to Fig. 2.: Having given the

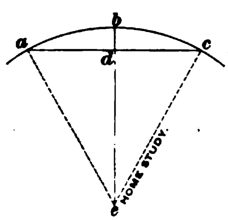


FIG. 1.

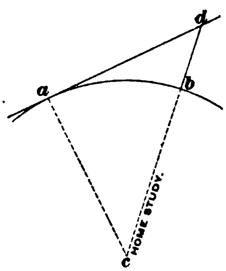


FIG. 2.

arc ab, its radius and length in degrees, and the tangent ad, how is the length of the radial extension bd determined?

C. F. L., Rochester, N. Y.

ANS.—In Fig. 1,

$$ad = ae \sin aed = ae \sin \tfrac{1}{2} aec;$$

Therefore, $ac = 2ad = 2ae \sin \frac{1}{2} aec.$

Also, $de = ae \cos aed = ae \cos \frac{1}{2} aec.$

Hence, $bd = ae(1 - \cos \frac{1}{2} aec).$

In Fig. 2, $cd = ac \sec acb$;

therefore,

$$bd = cd - cb = cd - ac = ac\,(\sec acb - 1).$$

***

(276) (a) In an engine directly coupled to a dynamo, where would you look for excessive thumping? (b) What would cause lifting of water and consequent flooding of the cylinder in a dynamo engine? (c) How would you line up the engine with the armature shaft of a direct connected machine? (d) How is constant and regular running of the engines driving a dynamo best obtained?

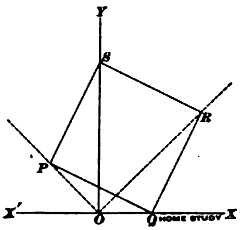
H. K. H., Boston, Mass.

ANS.—(a) In the crank head or crosshead. (b) If this occurs only occasionally the variation in the water level and the steam pressure of the boiler may account for it. Perhaps you are asking the boiler to do too much. (c) Remove the shafting and line up the boxes by inserting shims under the lower box, or pedestal. (d) By a centrifugal flywheel governor.

***

(277) A square is moved so as to always have the two extremities of one of its diagonals upon two fixed straight lines at right angles to each other; show that the extremities of the other diagonal will at the same time move upon two other straight lines at right angles to each other. Please solve by analytical geometry.

F. L. C., Mystic, Conn.



ANS.—Let $PQRS$ be any position of the square. Take the fixed lines on which the extremities of the diagonal QS move as coordinate arcs. Let $OQ = x'$, $OS = y'$, $\tan XQR = m$, and $\tan XQP = n$. Then, we know that

$$\tan RQS = \tan SQP = \tan 45^\circ = 1.$$

The equation of QR is $y = m(x - x')$ (1)

The equation of QP is $y = n\,(x - x')$ (2)

The equation of SR perpendicular to QR is

$$y - y' = -\frac{x}{m} \qquad (3)$$

The equation of SP perpendicular to QP is

$$y - y' = -\frac{x}{n}. \qquad (4)$$

Solving (1) and (3), we get the coordinates of R to be

$$x = \frac{m(mx' + y')}{m^2 + 1},\ y = \frac{m(my' - x')}{m^2 + 1};$$

therefore,

$$\frac{x}{y} = \frac{mx' + y'}{my' - x'}. \qquad (5)$$

The equation of QS is

$$y = -\frac{y'}{x'}(x - x'). \qquad (6)$$

Hence, $\tan XQS = -\dfrac{y'}{x'}.$

Now, $\tan RQS = \tan(XQS - RQS) =$

$$\frac{\left(-\frac{y'}{x'}\right) - m}{1 + \left(-\frac{y'}{x'}\right)m} = \frac{mx' + y'}{my' - x'} = 1.$$

Comparing this with (5), we get $\frac{x}{y} = 1$; thus, R lies on the line $\frac{x}{y} = 1$, or $x = y$, which is the bisector of the angle XOY. Solving (2) and (4), we get the coordinates of P to be

$$x = \frac{n(nx' + y')}{n^2 + 1},\ y = \frac{n(ny' - x')}{n^2 + 1};$$

whence,

$$\frac{x}{y} = \frac{nx' + y'}{ny' - x'}. \qquad (7)$$

And $\tan SQP = \tan(XQP - XQS) =$

$$\frac{n - \left(-\frac{y'}{x'}\right)}{1 + n\left(-\frac{y'}{x'}\right)} = \frac{nx' + y'}{x' - ny'} = 1.$$

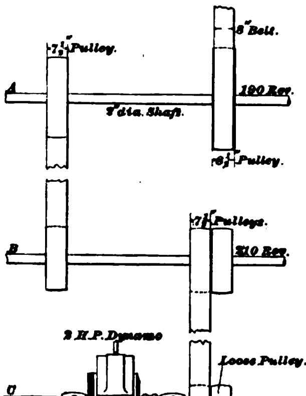
Comparing with (7), we get $\frac{x}{y} = -1$; accordingly P lies on the line $\frac{x}{y} = -1$, or $x + y = 0$, which is the bisector of the angle YOX'.

***

(278) I enclose sketch of shafting and belts. What I want to know is: Does the frictional resistance offered by the shaft in its bearings increase with increase of load? In other words, will there be more friction in the bearings of shaft B, when it is driving

the dynamo, than when—running at the same speed —the dynamo is stopped and the belt is on the loose pulley? J. S. F., New Bedford, Mass.

ANS.—Yes; there will be an increase of friction corresponding to the increase of pressure on the bearings. Friction depends upon the nature of the surfaces in contact and the pressures between them. If you double the pressure, the friction is doubled. In your case, when the dynamo belt is on the loose pulley, it exerts but a small pull on the shaft B; this pull, however, is transmitted to the bearings on the shaft, and there produces a certain amount of fric-



tion. When the dynamo is being driven, the pull in the belt may be increased, say, ten times, in which case the pressure, caused by this belt, on the bearings of shaft B and, consequently, the frictional resistance, will be multiplied by 10. The pressure on every bearing between the dynamo and the engine will be increased.

***

(279) (*a*) Please give me a formula for obtaining the diameter of an eccentric rod. You are to suppose that all the necessary data are known. What data *are* necessary, and how then is the diameter calculated? (*b*) Cloth requiring to be dried is passed around metal cylinders $\frac{1}{16}$-inch thick, and heated on the inside with steam of 7 pounds pressure. One of the cylinders is of copper, the other of turned steel. Which will dry the cloth the more quickly? How is it dried—by radiation, by conduction, or by both?
H. W. B., Philadelphia, Pa.

ANS.—(*a*) We require to know the load on the rod due to the friction of the valve on its seat.

Let R = the load;
L = length of the rod;
D = diameter.

Then $$D = \frac{\sqrt{LF}}{4},$$

where $$F = \frac{\sqrt{R}}{33}.$$

The resistance of the valve to motion depends on the total pressure on the valve, on the materials of valve and seat, the state of their surfaces, and the efficiency of lubrication. With very heavy valves working vertically, their inertia, also, has considerable effect. If you know the size of valve (or the unbalanced area if of the "unbalanced type"), the pressure, and the coefficient of friction for the particular surfaces in question, you can find R. Then find the value of $\frac{\sqrt{R}}{33}$. Insert this in place of F in the formula. (*b*) The copper will dry the cloth more quickly of the two. The cloth, where actually in contact with the metal, is dried by conduction. Where it does not touch the cylinder, it is dried by radiation. The heat passes through to the outer side of the cylinder by virtue of the conducting power of the metal.

***

(280) How many horsepower are available from an 8-foot fall of water running 30 cubic feet per minute? G. C. E., Roswell.

ANS.—The horsepower may always be found by the following formula, in which P is the pressure in pounds per square foot, and V is the volume displaced in cubic feet per minute: $H = \frac{PV}{33{,}000}$. In this case, $P = 62.5 \times 8 = 500$ pounds per sq. ft.; hence, $H = \frac{500 \times 30}{33{,}000} = \frac{5}{11}$ H. P. This result is the theoretical horsepower, the actual horsepower depending on the efficiency of the motor. If you use a turbine of the best make, the efficiency might be, say, 88 per cent., in which case the actual horsepower would be $\frac{5}{11} \times .88 = .4$ H. P.

***

(281) (*a*) How are the change gears of a lathe figured out? (*b*) I have seen an arrangement of three mirrors which, when placed outside a window, enable you to see people coming either up or down the street. How are the mirrors put together to reflect the people in this way? F. K., New York City.

ANS.—(*a*) We recommend you to purchase a copy of HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., for April. In it you will find an article entitled "Figuring Change Gears for Lathes." (*b*) The arrangement of the three mirrors is shown in Fig. 1. It consists of two mirrors a and b which are joined at an angle of 45°, and a third mirror c, which is placed in such a position that its center line is exactly opposite the joining line of a and b, and about 3 to 4 inches away. Fig. 2 shows the arrangement and how it works, D representing a pedes-

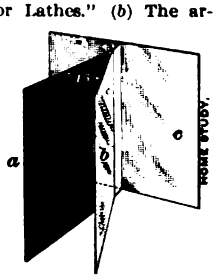


FIG. 1.

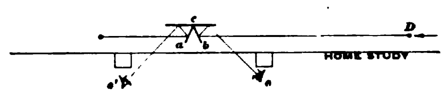


FIG. 2.

trian approaching the mirrors in the direction the arrow points. His image received on b is reflected on to c, and thence to the eye of observer e as indicated. His reflected image moves along the mirror c as he proceeds, until the image of his back is reflected from a to c and thence to the eye of the observer e'. You will find an article giving the laws of reflection, etc., in HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., July, 1897, entitled "Light."

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(282) (*a*) Please give me a good rule for testing cylinder and engine oil. (*b*) Where can I get a table for finding the resistance and safe carrying capacity of iron, copper, and German-silver wire from No. 0 to 36? E. A. A., Granite Falls, Minn.

ANS.—(*a*) This question cannot be satisfactorily answered within the limited space allowable here. Probably an article will appear at an early date, dealing with the various tests usually applied—identification, density, viscosity, etc. (*b*) We do not know of any more comprehensive table than that contained in the "Mechanics' Pocket Memoranda," (published by the Colliery Engineer Company, Scranton, Pa.) which gives the carrying capacity of wires from No. 0000 to No. 20—a table sufficient for all ordinary requirements.

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(283) Will you please tell me how to figure the receiver pressure, having given the volume and point of cut-off in the high-pressure cylinder, the boiler pressure, and the volume and point of cut-off in the low-pressure cylinder?

B. M. W., San Francisco, Cal.

ANS.—This can be done only approximately, by assuming that steam expands according to Mariotte's law, $pv = p_1 v_1$; this will give results sufficiently close for practical purposes.

Let p_1 = initial pressure in the high-pressure cylinder;
p_2 = terminal pressure in the low-pressure cylinder;
p_3 = pressure in the receiver = initial pressure in the low-pressure cylinder;
v_1 = volume of high-pressure cylinder;
v_2 = volume of low-pressure cylinder;
v_3 = volume of receiver.

All the above pressures are absolute pressures, i. e., gauge pressures + 14.7. Also, let n_1 = number of expansions in the high-pressure cylinder; then, the total number of expansions $= n_1 \times \frac{v_2}{v_1}$, and the terminal pressure in the low-pressure cylinder =

$$p_2 = p_1 \div \frac{n v_2}{v_1} = \frac{p_1 v_1}{n_1 v_2}.$$

Denoting ratio of real cut-off in the low-pressure cylinder by r_2, the pressure at cut-off in the low-pressure cylinder =

$$\frac{p_2}{r_2} = \frac{p_1 v_1}{n_1 r_2 v_2}.$$

The volume of steam behind the piston of the low-pressure cylinder at cut-off is $v_3 + r_2 v_2$, and at admission v_3; hence, the initial pressure in the low-pressure cylinder = pressure in receiver (neglecting clearance) =

$$p_3 = \frac{p_2}{r_2} \times \frac{v_3 + r_2 v_2}{v_3} = \frac{p_1 v_1 (v_3 + r_2 v_2)}{n_1 r_2 v_2 v_3}.$$

For example, if the boiler pressure is 125 pounds per square inch, we allow a drop of 5 pounds between boiler and engine, the initial pressure will be $125 - 5 + 14.7 = 134.7$ pounds, absolute. Suppose the volume of the receiver is 1¾ times that of the high-pressure cylinder; volume of low-pressure cylinder is 2.9 times that of the high-pressure cylinder; real cut-off in high-pressure cylinder is $\frac{1}{3.2}$; real cut-off in low-pressure cylinder is ½. Then, $p_1 = 134.7$, $v_1 = 1$, $v_2 = 2.9$, $v_3 = 1.75$, $n_1 = \frac{1}{r_1} = 3.2$, $r_2 = \frac{1}{2} = .5$, and

$$p_3 = \frac{p_1 v_1 (v_3 + r_2 v_2)}{n_1 r_2 v_2 v_3} = \frac{134.7 \times 1 \ (1.75 + .5 \times 2.9)}{3.2 \times .5 \times 2.9 \times 1.75} =$$

53.08+ pounds per sq. in., about.

***

(284) (*a*) What materials would you use, and in what proportions, to cement the floor of a cellar? Of what should the top surface be made, so that it will not be brittle or likely to crack? How thick should each layer be? (*b*) How much of each material will be required for a floor that is 20 feet by 30 feet? The cellar is not very wet, but I wish to keep it less damp and the floor more suitable for shifting articles about upon, without plowing up the soil every time.

R. W. B., College Point, N. Y.

ANS.—(*a*) The natural cellar floor should be rolled or tamped until it is well settled. If the cellar bottom is loamy and moist, it should be covered with a 4-inch or 6-inch layer of coarse gravel or fine broken stone. On this should be spread a layer of concrete, 4 inches thick, of the following composition: Mix together 1 part of cement, 3 parts of sand and 6 parts of gravel; add sufficient water, and work thoroughly to the consistency of stiff mortar. Commence laying the concrete at one end, and tamp it thoroughly as the work proceeds. After the concrete has set, the top surface should be wet and the finishing coat applied. The surface, or finishing coat, should consist of 1 part sand, and 1 part of the best Portland cement, mixed dry, moistened and worked to the consistency of a good plastic mortar; it should be spread with a trowel to the thickness of 1 inch, and leveled between straight edges, or *screeds*, as they are called. The coating should then be thoroughly floated, carefully smoothed, and allowed to dry slowly, in order to insure a homogeneous solidification without cracks. (*b*) The 4-inch bedding for the concrete, of either coarse gravel or fine broken stone, will require about 45¾ barrels. There will be required for the concrete 7¾ barrels of cement, 23 barrels, or 3¾ cubic yards of sand, and about 45¾ barrels, or 7½ cubic yards of gravel. For the finishing, or top coat, 1 inch thick, about 11 barrels of Portland cement and 11 barrels of sand will be required. In the above estimate, a barrel has been figured as containing 3½ U. S. struck bushels, or about 4.37 cubic feet. In the event of the finishing coat being ½ inch thick, which is the usual thickness for dwelling-house work, one-half only of the quantities given will be required.

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(285) (*a*) How much power can be obtained from a stream of water, flowing through a flume 2 feet 6 inches wide by 2 inches deep, under a head of 3 feet 6 inches? It is two inches deep at the point where it flows over the top of the flume board. We have no way of measuring the amount of water which flows through the flume per hour. (*b*) Which would it be advisable to use—an overshot or a breast wheel? (*c*) What size and number of buckets would you recommend?

E. G. L., Campgaw, N. J.

ANS.—(*a*) Not knowing the length of the flume, the velocity of the water cannot be estimated. Assuming, however, a mean velocity of 5 feet per second, the quantity of water flowing per minute is

$$2\tfrac{1}{2} \times \tfrac{1}{6} \times 5 \times 60 = 125 \text{ cu. ft.},$$

or

$$125 \times 62\tfrac{1}{2} = 7{,}812.5 \text{ lb.},$$

and the theoretical horsepower is

$$\frac{7{,}812.5 \times 25}{64 \times 33{,}000} = .092 \text{ horsepower}.$$

This, it must be understood, is the theoretical horsepower of the water, as it flows over the top of the flume board. We cannot answer (*b*) and (*c*) without knowing more of the conditions. An expert on the spot would be able to give you the most valuable advice.

***

(286) Please explain the following formula, found in the handbook of Buff and Berger, of Boston, Mass.:

$$\sin Z = \frac{\text{sine of polar distance}}{\text{cosine of latitude}}.$$

T. H. A.

ANS.—This formula is used for determining the true meridian, or the true north-and-south direction at any place. *Z* is the azimuth of Polaris at its greatest elongation, that is, the angle between two vertical planes, one of which passes through the star and the place of the observer, and the other is a north-and-south plane. The times of greatest elongation of

Polaris are given in books on surveying. If Z is known, all that is necessary is to direct the transit towards Polaris when at its greatest elongation, and then deflect the instrument through an angle equal to Z; this will bring the transit into the true meridian, and a line run on the ground in this direction will be a true north-and-south line. Hence the importance of knowing the value of Z. A table of values of Z between latitudes 25° N. and 50° N., and between the years 1895 and 1910, is given in Johnson's "Theory and Practice of Surveying." If no table of azimuths is at hand, Z may be computed from the preceding formula. The latitude is usually known, or it can be found by observation. [See HOME STUDY MAGAZINE, May, 1898, Answers to Inquiries, No. 158]. The polar distance is the angular distance from Polaris to the pole, measured on a great circle through the star and the pole. A table of polar distances of Polaris between the years 1885 and 1930 is given in Johnson's book, referred to above. For the year 1897 it was 1°-14'-30". An approximate value of other years may be found by subtracting 19" for every year.

* * *

(287) Take a room in a schoolhouse, 30 feet wide, the floor joists of which would be 2" × 10", or 2" × 12", or 3" × 14". If I were to trust my own instinct, I would use a 3" × 14" joists placed 12 inches apart, center to center. What would be the safe load per square foot for such joists so placed to carry? Please answer this question by simple arithmetic.

J. O'C., Buffalo, N. Y.

ANS.—The inquirer has failed to state of what kind of wood the joists are composed. It will therefore be necessary to assume, say, yellow pine. The formula for determining the safe load of a rectangular beam is $\frac{4FBD^2}{3L}$, where F is the safe fiber stress of the material (which for yellow pine, with a factor of safety of 4, would be about 1,825 pounds); B, the breadth in inches; D, the depth in inches; and L, the span of the beam in inches. Hence, for a 3" × 14" yellow-pine joist with a 30-foot span we would have

$$\frac{4 \times 1{,}825 \times 3 \times 14^2}{3 \times 30 \times 12} = \frac{4{,}292{,}400}{1{,}080} = 3{,}974 \text{ lb.}$$

= safe load for each joist; and, as the joists are 1 foot apart, and 30 foot span, $\frac{3{,}974}{30}$, or 132 pounds, would be the safe load per square foot of floor area, including the weight of the beam itself and flooring. However, a 3" × 14" yellow-pine beam with a span of 30 feet would be likely to deflect under this load—as much as 2 inches at the center—and would neither make a stiff nor a safe floor. It would be better to place steel beams or heavy wood girders across the 30-foot span, and run the floor joist in the other direction, or else support the floor from beneath by a longitudinal partition or girder carried on posts.

* * *

(288) Furnaces for burning coal are usually lined with some non-conducting material. This is done, I believe, to retain the heat and secure more perfect combustion. (a) Why are not wood-burning furnaces similarly lined? (b) Would it not pay? (c) How can perfect combustion of wood be obtained? (d) Can you tell me of any good books that treat upon these subjects, and where I can obtain them?

F. W. C., Wyoming, Iowa.

ANS.—(a) Coal- and wood-burning furnaces, when properly built, are practically identical, except for the larger firebox of the wood burner. (b) It certainly would pay. (c) Perfect combustion of any solid or liquid fuel is a practical impossibility. (d) "The Calorific Power of Fuels," by Herman Poole, $3.00, can be obtained from The Technical Supply Co., Scranton, Pa.

(289) Kindly inform me how to determine the horsepower of a running stream of water having a uniform depth of 6 feet, a width of 8 feet, and a surface velocity of 5 feet per second.

E. Z., Port Jervis, N. Y.

ANS.—To find the theoretical horsepower, it will first be necessary to find the average velocity of the current and the theoretical head. The average velocity of the current is found approximately by multiplying the surface velocity by .8; in this case, therefore, it will equal $5 \times .8 = 4$ feet per second. The theoretical head is equal to $v^2 \times .0155$, where v is the current velocity in feet per second. In this case $v = 4$; therefore, the theoretical head $= 4 \times 4 \times .0155 =$ .248 feet. The total horsepower =

$$\frac{C \times H \times W}{33{,}000}$$

in which C = cubic feet of water per minute;
H = vertical height in feet;
W = weight of a cubic foot of water = 62.5 pounds.

Therefore,

$$\text{H. P.} = \frac{(6 \times 8 \times 4 \times 60) \times .248 \times 62.5}{33{,}000} = 5.41.$$

How much of this horsepower would be available, depends on the method chosen for utilizing it. With an ordinary undershot wheel the power that could be developed would be very small, probably not more than 1 horsepower.

* * *

(290) Will you please inform me how the tables of natural sines, cosines, tangents, and cotangents, are constructed? O. A. M., Port Richmond, N. Y.

ANS.—You will find this question answered in HOME STUDY MAGAZINE, October, 1897, Answers to Inquiries, No. 365.

* * *

(291) How are the sizes of sprocket wheels figured, the number of sprockets and the length of a link of the chain being known? E. C. P., Lawrence, Mass.

ANS.—Multiply the length of the link by the number of teeth and divide by 3.1416. This will give you the pitch diameter of the sprocket wheel.

* * *

(292) What is the meaning of the abbreviations, "Thesaur. Amer. Septent. Sigil." on the red seal of our paper money? L. A. B., Elmira, N. Y.

ANS.—They are contractions for

Thesauri	Americæ Septentrionalis	Sigilla
of the treasury	of North America	the seal

"The seal of the treasury of North America."

* * *

(293) Is there any metal or composition of metal which a magnet will not draw through?

M. M., Everett, Wash.

ANS.—There is no material that is impervious to magnetism. Bodies cannot be insulated from magnetism, but the lines of force, if they are not too dense, may be diverted from a body by a shield of some magnetic substance. Watches are "insulated" from magnetism by a shield of this kind.

* * *

(294) In Vol. II of Bound Volumes of the Complete Mechanical Scholarship of the International Correspondence Schools, on page 1123, a separator calorimeter is described (Fig. 578). What are the sizes of the pipes B, S, S', A, W, and what is the length of A? What proportions would be most convenient and give good results, so that the apparatus could be easily worked from place to place?

W. E., Anniston, Ala.

ANS.—Pipes B, S, and S', $\frac{3}{4}$"; pipe W, $\frac{1}{2}$" or $\frac{3}{4}$"; pipe A, $1\frac{1}{2}$" or 2" in diameter and 8" to 12" long between the fittings into which it is screwed. These sizes are standard sizes of wrought-iron pipe, not actual sizes.

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HOME STUDY MAGAZINE.

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HIGH RAILROAD SPEEDS.*

H. Rolfe.

CONDITION OF THE ROLLING STOCK—TRAFFIC AND OPERATING DEPARTMENTS—WIND AND WEATHER—TRAIN RESISTANCE.

THE next point to be considered is *the condition of the rolling stock.* This term includes only the cars themselves, the locomotives being dealt with separately.

In the first place, all car wheels should be in good balance; and they should not be allowed to get too badly worn before re-turning. Wheels whose faces are worn, until they contain a multitude of flat places are, as the brakes are improved and trainmen become more expert in handling them, getting rarer.

Another matter that repays careful attention is lubrication. It is now pretty generally known that American rolling stock, when in proper condition, is the easiest running in the world. This is largely due to the attention that has been paid to lubrication. A few years ago, a great proportion of the passenger cars in Europe ran with grease boxes instead of oil boxes. Such trains were very hard to pull in cold weather, especially for the first few miles. The bearings *had* to get hot, before the grease would run at all. A good proportion of their passenger and nearly all their freight cars use grease instead of oil even now.

Another point about American stock that conduces to easy pulling, is the universal use of trucks. These adapt themselves to the curves and so enable the cars to traverse them with comparative ease.

In the case of European cars with rigid wheel bases, there is considerable grinding of the flanges against the rails, which consumes power and thus retards the speed of the train. This—the use or non-use of radial rolling stock—is, perhaps, the most important and vital difference in the practice of the two continents.

Another bad feature in European stock is the use of side buffers. Where a train is made up once and for all—that is, where the same cars always constitute that particular train—the cars are "close coupled" with a central coupling and buffer, and are all right. But where the stock is fitted with the old style side buffers and screw couplings, there is a loss of power; for, when rounding sharp curves, the buffer springs on the *inner* side of the curve are forcibly compressed, and the buffers slide and grind harshly against each other. Sometimes, on extra sharp curves, the buffer heads are jammed right home against the buffer castings, and would go in still further if they could. It is easy to see that all this increases the demands on the engine when running on curves.

Great care is, as a rule, exercised in the selection of springs. The effect of a bad set of springs—whether too stiff or too weak—is perhaps more noticeable as affecting the comfort of the passengers than the speed of the train. But, evidently, all rough riding must act against the engine; and springs that are either wrong in themselves—badly made or tempered—or are unsuited to the loads may, especially if the track is bad, cause an amount of rolling and surging sideways that will be anything but a help to the engine.

The Traffic Department.—As regards accelerating the speed of transit, taking a journey as a whole, it may be remarked that much

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* *Begun in the April Number.*

can be contributed by other departments than that to which the motive power belongs. If the schedules can be arranged so as to give a train a clear road throughout, without any side-tracking—to allow, for example, a coal train to pass—the good work is helped along considerably. Train despatchers, baggagemen, conductors, etc., can all materially assist. Many a brilliant run has been spoiled, almost at the last stage, by late connections.

It is, above all, absolutely essential that the various branches of the operating and traffic departments pull together. In England, the "traffic" and the "loco" are always at loggerheads, each blaming everything on to the other. If time is lost during a run, the guard always blames the driver, who, in turn, says it is the fault of the guard. If the driver makes a good run the guard gets both the credit and the "tip," which naturally upsets the equanimity of the men on the footplate. And so, also, higher up in the scale of officialdom, if an important train is very late, *traffic* swears that it's *loco's* fault, and *loco* declares that *traffic's* to blame.

Again, the permanent-way people complain that the increasing weight of "locos" together with bad balance, batters their bridges down and destroys their track; the "loco" men retort that the badly laid and kept track shakes their engines to pieces. And so they go on. Happily things are better in this country.

Wind and Weather.—That the state of the weather affects the question of speed is doubtless well known. Frosty or snowy weather makes it very bad for the rails; damp, foggy weather makes the rails "greasy" as the enginemen term it, producing in fact, a worse effect than a prolonged heavy rain. The latter thoroughly washes the rails, and causes the adhesion of the wheels to be greater than when only a slight rain has fallen, although, of course, there is still some loss through slipping, as water acts more or less as a lubricant, where metals are concerned. An engine often loses time when going up hill in wet weather; so also when running through a tunnel that leaks badly, as some of them do, for the water that drips onto the rails is sufficient to make them "greasy" but never enough to cleanse them as a heavy rain would. A tunnel, up grade, in damp weather, is a bad combination to encounter, making it difficult for an engine to "hold her feet," especially if loaded up pretty near her capacity.

In Great Britain, a sudden rainstorm is often the cause of wiring ahead for a pilot to be in readiness at the next depot where one is available.

As regards the *wind pressure*, nothing very definite is known at present. Without doubt, wind is a serious obstacle to the attainment of high speeds; even in a calm atmosphere the resistance is considerable—as is well known to any one who has dragged himself around to the front end of a locomotive when making 65 to 70 miles an hour. This air resistance is not very noticeable until after a speed of about 20 miles an hour is passed. The atmospheric resistance is twofold: There is the skin friction between the air and the sides and top of the moving train; and there is also the effort necessary to displace the air. The last item is the more serious one. A side wind is worse than a head wind, especially with trains that are not close coupled. In England, nowadays, a good many of the best trains are so coupled—there being only a few inches between adjoining cars. On our American lines, the cars are necessarily further apart, on account of the platforms; but this drawback is to some extent neutralized in vestibule trains. Not only does a side wind catch the front of each car and so retain it, but it also forces the train over to the lee side, thus causing a large amount of extra flange friction. This is no offspring of imagination. We remember a case where considerable trouble was experienced with flange wear on some cars that always ran on one particular route. They ran back over a different part of the system, so that they always had their one side turned in the same direction. It was found that the flanges on the left side were always worn the most, and at last it occurred to some one that a great part of the road lay through open districts where the prevailing winds—and they were strong winds too—were from the *right*, thus thrusting the cars over to the left side of the track. The route was changed so that the cars would make the return journey turned end for end; after that the flanges were found to wear even.

In Belgium, they seem to be imbued with a lively sense of the wind's retarding force, for they occasionally use a kind of shield on the front of the smokebox, and also in front of the stack, sand box, and dome. These shields are wedge-shaped arrangements presenting to the wind a cutting edge and an angular surface of about 80 degrees. These shields form only a portion of the total end

surface, and it is doubtful whether their utility as wind splitters is anything startling; still, it is a step in the right direction. Undoubtedly we should be facilitating the increase of speeds by providing, as far as possible, a smooth unbroken surface throughout the train—closing in the sides, having as plain a roof as practicable, and so on.

During the erection of the Forth Bridge, Sir Benjamin Baker made observations on the wind pressure with different sized screens. But even when the screens were placed close together, the respective readings varied, the pressure per square foot on a screen 16 feet square differing materially from that registered by one only 1 foot square. A number of experiments were made some time ago with electric cars running on a circular track. The speeds attained were very high, reaching, it was stated, 110 miles per hour. The results given out by the experimenter, Mr. Dashiell, were as follows:

Speed of Train. Miles per Hour.	Resistance of Air. Pounds per Sq. Ft.
50	7.5
60	9.0
70	10.5
80	12.0
90	13.5
100	15.0
110	16.5

They show the force exerted by the resistance of air on a square foot of end surface. In view of the Forth Bridge experiments, they can be regarded as a guide only, because with the different existing sizes of exposed end surfaces in trains, the pressure per square foot will undoubtedly vary. The end surface of what may be called *full-size* locomotives—taking the cab into account—varies from 70 to 100 square feet. If the end of the car presents more area to the wind than does the engine, then it becomes the ruling factor in the question.

Future experiments will doubtless throw light into dark places. We can however here give some results under the general head of train resistance.

Train Resistance.—This is a burning question, in which, however, considerable investigation has been made of late. It is being clearly shown that utterly erroneous views have been held on this matter. It was laid down as a law many years ago, that the resistance of a train increased as the square of its speed, and on this basis, people thenceforth reasoned, sometimes with results that were very unsatisfactory to, at least, one of the parties concerned. A year or so ago, a marvelous run was made in one of the northern states by a 6-coupled engine with small wheels, a speed of about 70 miles an hour being maintained for nearly 90 miles. The results in this particular case certainly seem to be far from standing on the same firm basis as certain records made by New York Central and Atlantic City trains, for instance. In fact, the officials themselves, when questioned, seemed reluctant to endorse everything that was given out to the world. Be that as it may, there was much criticism in European circles, criticism that was rather weakly founded; but then, they always do look askance on any "fast runs" that are made on this side unless vouched for by some recognized authority.

Well, in this particular case, certain writers took what they thought was the total train resistance, and then, multiplying by the speed, they found that the engine must have developed between 2,000 and 3,000 horsepower; and as, of course, the boiler could not possibly have supplied steam enough to meet such a demand, the critics waxed exceeding wroth. But they happened to be on the wrong track, for they based their calculations on the old assumption that the train resistance varies as the *square* of the speed. The fact is the resistance does *not* increase in this ratio. Besides, our rolling stock runs much easier than that in Europe.

The one thing to be said in extenuation of their attitude, is that the speed was attained by an engine which was the very antipodes of what is associated in their minds with fast running. It was of exactly the same type as is used in Europe for freight traffic, namely, 6-coupled, with small wheels. The fact of its having a truck in front, (which the European have not) doesn't affect the argument. *Their* idea of a flyer is an engine with a single pair of large drivers; in this type—to mention two advantages—they secure low piston speed and free running.

Latterly, tests have been made with indicators, dynamometers, wind gauges, etc. The results of some of these tests will form the subject of the third part of this article, in next month's issue.

(*To be Continued.*)

GAS-ENGINE INDICATOR DIAGRAMS.

E. W. Roberts.

DEFECTS SHOWN BY THE DIAGRAM—FAULTS OF EARLY AND OF LATE IGNITION—REMEDIES SUGGESTED.

THE gas-engine diagram does not immediately end its usefulness when from its area and length, as described last month, the I. H. P. of the engine has been computed. It also serves as an index to what is taking place in the cylinder during the time that the diagram is being produced. An engineer who is thoroughly familiar with the operation of the gas engine can usually locate a defect much more quickly from an examination of its diagram than from a tedious examination of the engine itself.

The diagrams shown here are, with one exception, exact and full-sized copies of actual diagrams in the writer's possession. Diagram *A* was taken from an oil engine using ordinary kerosene oil. The cycle is the same as the Otto gas engine, and the diagram is shown as an excellent example of what a good gas-engine diagram should be like. That there is very little constriction in the admission and exhaust passages is shown by the curved lines that lie close to and just above and below the atmospheric line *x y*. These show but little rise or fall of pressure. The curve above the atmospheric line, if high, would show resistance in the exhaust passages, and that below the atmospheric line would show resistance in either the gas passages, the air passages, or both.

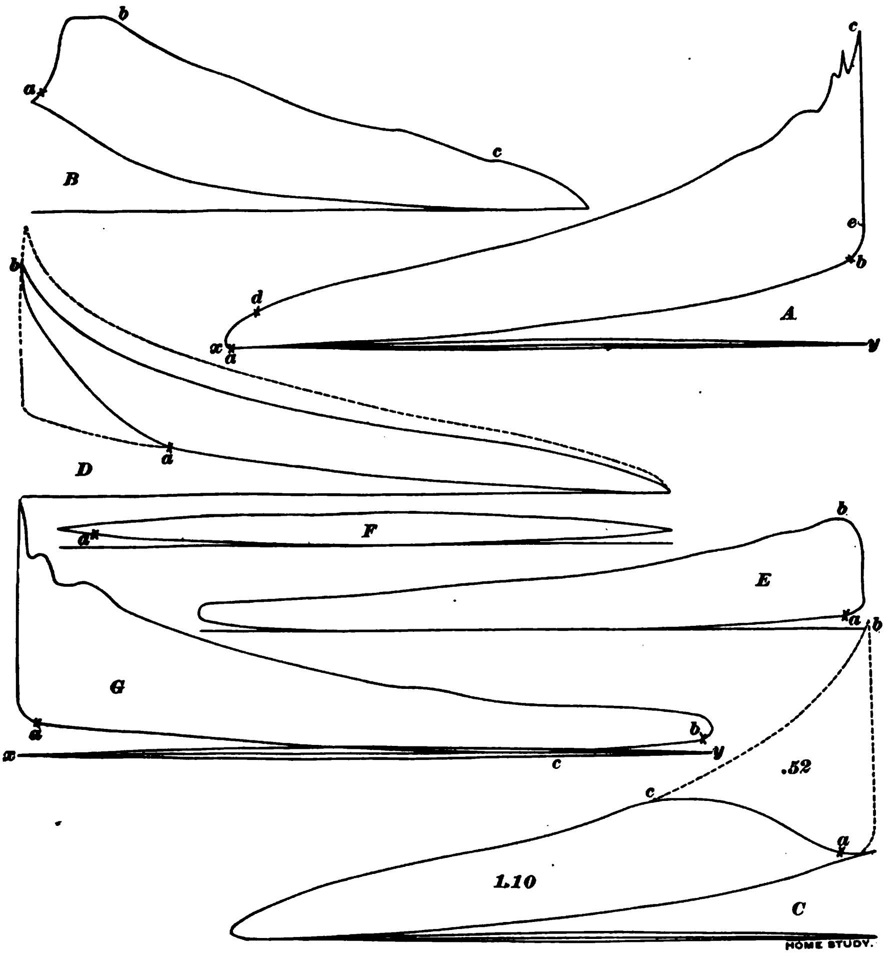
Compression begins at *a*, and the pressure of the charge is gradually increased until, just before the piston reaches the end of the compression stroke, the charge is ignited at *b*. The point *b* of ignition is shown by the sudden change in the direction of the compression line. The advantage gained by ignition taking place just before the completion of the compression stroke is shown by the line *e c*. This line is at right angles to *x y* proving conclusively that the charge was fully inflamed before the piston started on its forward stroke, this being, as it should be, the point of maximum pressure—at the beginning of the stroke, just before the piston starts forward.

The ragged appearance of the diagram at the beginning of the forward stroke is not due to any fault of the engine, but to vibration of the indicator spring, caused by the rapid rise of pressure from *e* to *c*. The curve would otherwise be quite regular from *c* to *d*. The fall from *c* to *d* is gradual, and the form of the diagram after release at *d* shows a quick-opening exhaust valve and very little resistance in the exhaust passages.

An example of late ignition is shown on diagram *B*. Ignition takes place at *a* just after the crank has passed the center. The result is that the initial pressure is much below what it should be, and the maximum pressure occurs too late in the stroke. The effect of this derangement is shown more distinctly in diagram *C*, where ignition takes place much later in the stroke. The dotted line shows the shape of the diagram obtained when ignition takes place at the proper point, the area *a b c* being the measure of the power lost. The areas are indicated by the figures on the diagram, .52 being the area of *a b c*, and 1.10 that of the actual diagram. This shows that very nearly ½ of the available power has been lost through faulty ignition.

Bad as late ignition is, too early firing is no better, because it checks the speed of the engine and causes an injurious pounding. It may even cause a reversal of the engine at low speeds and light loads. A diagram illustrating the effect of too early ignition is shown at *D*. The excessive back pressure from *a* to *b* is very much in evidence. Too early ignition also gives the cylinder walls a chance to carry off an excessive amount of heat, owing to the slow speed of the piston at the end of the stroke. The diagram produced lies inside that obtained when the ignition is properly timed. The loss of work is shown by the difference in the two diagrams, and is plainly marked. Fortunately, this is a condition promptly made evident by the behavior of the engine, and is soon remedied.

The reader should be careful not to confuse diagrams produced by badly timed ignition with those produced by weakened mixtures. Examples of the latter are shown in diagrams *E* and *F*. In both of these, ignition takes



place at a, but in diagram F the maximum pressure is not reached until the piston is at the middle of its stroke. In E the maximum pressure occurs a trifle late, but it should be noted that the line $a\,b$ is at right angles to the atmospheric line. The later occurrence of the maximum pressure is due, not to faulty timing of the ignition, but to the fact that flame propagation is slower in weak mixtures, and particularly when the compression pressure is low. The engine from which these diagrams were taken, governs by the system of throttling both the gas and the air.

Diagram G indicates very clearly that the exhaust passages are obstructed. The point b should be on the atmospheric line $x\,y$, as shown in A at x. Instead, the line of the diagram does not reach $x\,y$ until the piston returns to c. This may be due to a sluggish opening of the exhaust valve or to constricted exhaust passages. Some forms of exhaust mufflers will cause the production of such a card.

Several of these defects may occasionally appear on one diagram. They are all more or less detrimental to the proper performance of the engine. The remedy will usually suggest itself in every case. Quite often the remedy consists in the adjustment of the igniter mechanism or the proper setting of the valves. Sometimes, however, it will not be possible to apply the remedy, except to a new design.

STRESSES IN A BICYCLE FRAME.*

Benj. F. La Rue.

ASSUMED CONDITIONS OF LOADING THAT PRODUCE MAXIMUM STRESSES—DETERMINATION OF THE STRESSES BY MEANS OF STRESS DIAGRAMS.

SECOND CONDITION: *Load Partly on Handle Bars.*—It will now be assumed that one-fourth of the load, or 50 pounds, is supported upon the joint c_0, which may be taken as the approximate position of the handle bars, the balance of the load being supported upon the joint d_0. From moments we have

$$R_1 = \frac{150 \times 9.25 + 50 \times (43.5 - 12.5)}{43.5} = 67.5 \text{ pounds},$$

and

$$R_2 = \frac{150 \times (43.5 - 9.25) + 50 \times 12.5}{43.5} = 132.5 \text{ pounds}.$$

The stress diagram for this condition of loading is shown in Fig. 4. The construction of this diagram is substantially the same as that of Fig. 2, and will require no special explanation. By the aid of the notation, it can easily be followed through in detail. It will be noticed that this stress diagram gives the stress $c\,d$ slightly greater, the stresses $d\,f$ and $g\,a'$ considerably greater, and all other longitudinal stresses less than given by the diagram of Fig. 2. The force $a\,a'$, due to the bending moment in the members $G\,A'$ and $A'\,D$, is considerably greater, while the force $f\,g$, due to the bending moment in the members $D\,F$ and $G\,A'$, is materially less than the corresponding forces in Fig. 2.

Third Condition: Force Due to Application of Brake.—For this condition it will be assumed that, with the entire load of 200 pounds supported upon the joint d_0, and the bicycle traveling at a speed of 15 miles per hour, a sufficient horizontal force is applied against the joint a_0, through the medium of the brake acting upon the front wheel, to bring the bicycle to a full stop in a distance of 100 feet. For this condition, the momentum of the rider only is considered, that of the bicycle itself being neglected. In any strict investigation of the stresses, the momentum of the bicycle should of course be included; and this can be easily done, in substantially the same manner as here explained, by ascertaining approximately the distribution of its weight upon the various joints.

The force required to bring to rest, in a given distance, a given weight moving at a given velocity, may be computed as follows: Let it be assumed that

w = the weight;
m = its mass;
v = its velocity, in feet per second;
s = the distance;
f = required force;
g = acceleration of gravity = 32.2 feet per second.

From mechanics, we have

$$\text{Work performed} = f\,s;$$
$$\text{Energy} = \tfrac{1}{2}\,m\,v^2;$$
$$\text{Mass} = \frac{w}{g}.$$

By placing the work equal to the energy and transposing s, we may write

$$f = \frac{m\,v^2}{2\,s} = \frac{w\,v^2}{2\,g\,s}.$$

A velocity of 15 miles per hour is equal to

$$\frac{15 \times 5{,}280}{60 \times 60} = 22 \text{ feet per second}.$$

By substituting the velocity, weight, and distance in the above formula, we have the *accelerating* force necessary to impart this velocity to a body of the given weight, or the *retarding* force necessary to bring the body, when moving with this velocity, to a state of rest in the given distance. Denoting this force by f, we have

$$f = \frac{200 \times 22^2}{2 \times 32.2 \times 100} = 15 \text{ pounds, nearly}.$$

It will be considered as a horizontal retarding force applied at the joint a_0, and opposing an equal horizontal force applied at the joint d_0. The positions of the forces acting upon the frame, together with the stress diagram for this condition, are shown in Fig. 5. This stress diagram does not differ greatly from the diagrams of the preceding figures, and will require no special explanation. It is found that the stresses $a\,e$ and $b\,e$ are of the same magnitude as given by the stress diagram of Fig. 2, that the stresses $e\,d$, $a'\,d$, $d\,f$, and $g\,a'$ are slightly greater, and that the stress $c\,d$ is greater by about the amount of the retarding force $c\,h$. It is also found that the forces $c\,f$ and $f\,g$, due to the bending

* *Begun in the July Number.*

moment in the members DF and GA', are considerably greater, and that the forces gc and aa', due to the bending moment in the members GA' and $A'D$, are somewhat less than given by the stress diagram of Fig. 2.

Fourth Condition: Entire Load on Pedal.—For this condition it will be assumed that the rider is exerting so great an effort in propelling the wheel as to throw his entire weight of 200 pounds upon the pedal. It is probable that this condition does not often fully obtain, though it may not infrequently be approximated. The crank that carries the pedal is assumed to be in a horizontal position and to have a length of 7 inches. It is also assumed that the front, or crank-shaft, sprocket wheel has a pitch diameter of 8 inches, or a radius of 4 inches, and that the rear sprocket wheel has a pitch diameter of 3 inches, or a radius of $1\frac{1}{2}$ inches. The radius of the bicycle wheel is 14 inches.

The pull upon the driving chain is, therefore, equal to

$$\frac{200 \times 7}{4} = 350 \text{ pounds,}$$

and the backward thrust of the bottom of the driving wheel against the ground, or the forward reaction of the ground against the bottom of the wheel, is equal to

$$\frac{350 \times 1.5}{14} = 37.5 \text{ pounds.}$$

The combined effect of this pull of the driving chain and forward reaction of the earth upon the bottom of the driving wheel is resisted at the center of the wheel, or joint f_0; and, for the purpose of determining their effect upon the members of the frame, these forces may be considered as applied at that joint. We can now construct the stress diagram for this condition of loading—and a very interesting diagram it is found to be, showing conditions radically different from those as yet represented.

A diagram of the bicycle frame, showing the positions of the forces acting upon it, together with the stress diagram determining the stresses in its various members due to this condition, is shown in Fig. 6. The vertical reaction R_1 of the forward wheel is equal to

$$\frac{200 \times 25\frac{13}{16}}{43.5} = 118.7 \text{ pounds,}$$

and R_2, the vertical reaction of the rear wheel, is equal to

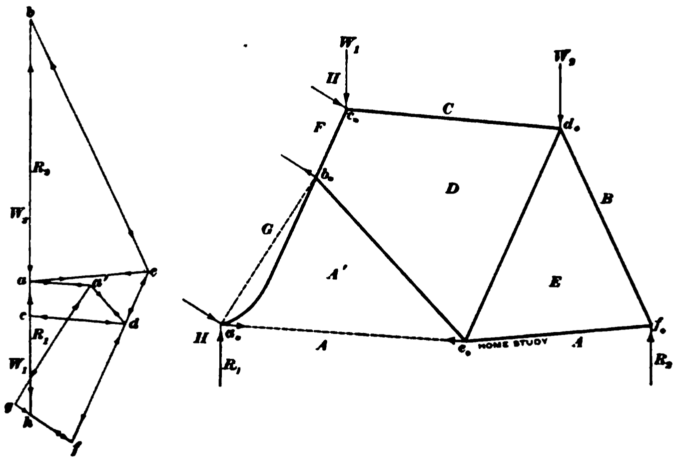


FIG. 4.

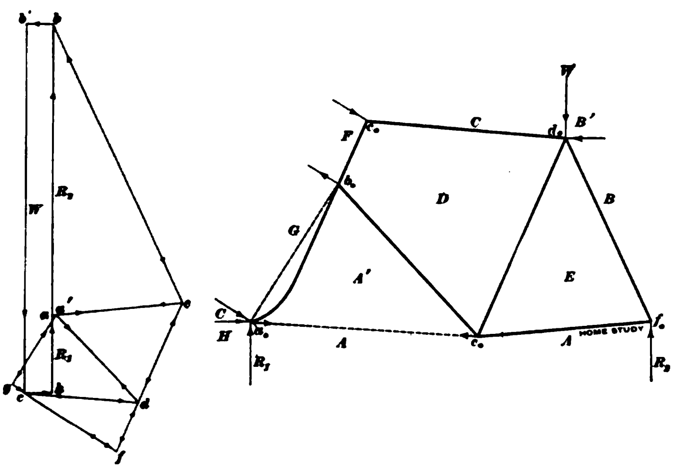
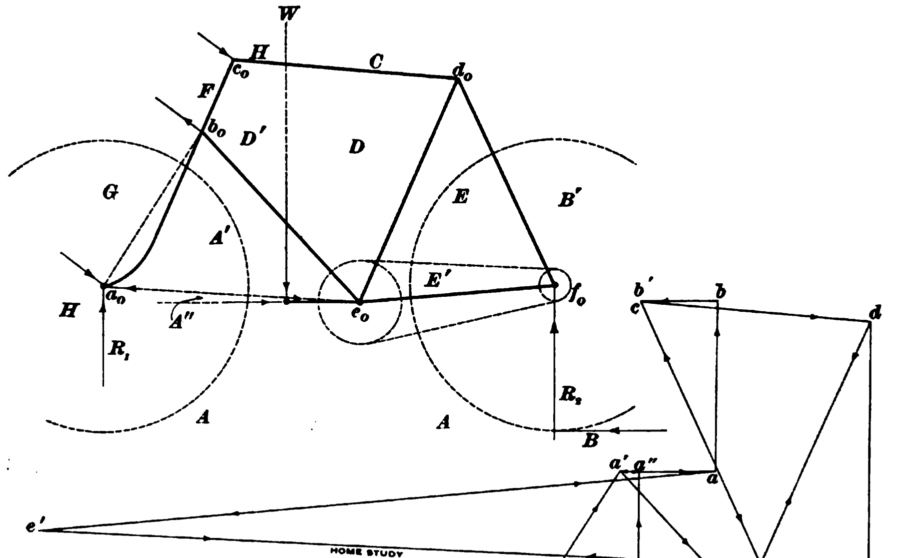


FIG. 5.

$$\frac{200\times(43.5-25\frac{13}{16})}{43.5}, = 81.3 \text{ pounds.}$$

The forces acting upon the joint f_0 are the vertical reaction AB of the rear wheel, as just found, the forward reaction BB' of the ground ($=37.5$ pounds), the pull EE' of the chain ($=350$ pounds), and the stresses in the two members $B'E$ and $E'A$ of the frame. The force polygon for this joint is $abb'ee'a$, determining the stresses $b'e$ and $e'a$ for the members $B'E$ and $E'A$, respectively. As there is no external force acting upon the joint d_0, the letters B' and C denote the same space, and $eb'cde$ becomes the force polygon for this joint, giving cd and de as the stresses in CD and DE, respectively. The forces acting upon the joint e_0 are the stresses in the three members of the frame connecting at the joint, the pull in the chain $E'E$, the vertical load DD', and an assumed horizontal force $A''A$ equal and opposite to the forward reaction of the ground against the driving wheel. As the resultant effect of the vertical load and the pull of the chain is exerted upon and resisted at the joint e_0, the forces may be considered to be applied directly upon the joint.

If a uniform speed is being maintained, the forward reaction of the ground against the driving wheel, or, in other words, the propelling force exerted upon the bicycle, must be resisted by an equal and opposite force. At times this force opposing the propelling force may be chiefly the resistance of the wind, while at other times it may be principally the resistance of the road; it will generally be more or less of both, together with the slight friction in the parts of the bicycle. In the present case, the opposing force is, for simplicity, assumed to be applied wholly upon the crank joint e_0, this being the joint upon which the rider is supported. Although this condition can never fully obtain, it will serve for present purposes.



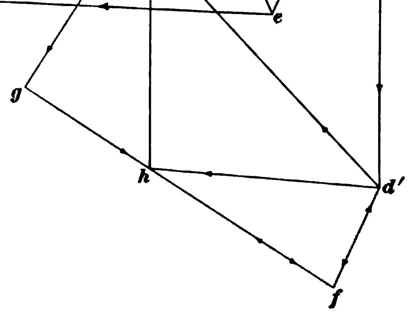


FIG. 6.

The actual conditions would have been approximated more closely by assuming the resistance to be distributed between the wheel, pedal, saddle, and handle-bar joints; but this would have rendered the explanation of the stress diagram rather more tedious, though the general form of the diagram would have been about the same. As this is not intended as a rigid investigation of the conditions, the entire resistance to propulsion is, for convenience, assumed to be concentrated upon the crank joint e_0. With this assumption, $ae'edd'a'a''a$ is the

force polygon for this joint, giving $d'a'$ as the stress in $D'A'$, and $a'a''$ as the force due to the bending moment in that member. The remainder of the stress diagram is so similar to the corresponding parts of the preceding ones as to require no explanation. It will be noticed, however, that the stresses obtained are in most cases considerably greater. Some of them differ also in character from those obtained by the preceding diagrams. For this condition of load, the member DE sustains tensile stress, and the member EA is subjected to a large amount of compression, whereas for all preceding conditions the stress in DE has been compressive and the stress in EA tensile stress. By the preceding diagrams the force AA', due to the bending moment in the member DA', has been of the nature of a pull upon the joints e_0 and a_0; whereas, by this diagram, it is of the nature of a push against those joints, showing that the bending is in the opposite direction.

The original stress diagrams, from which those of Figs. 2 to 6, inclusive, are reproduced, were drawn to a scale of 40 pounds to the inch. From these diagrams are obtained the following stresses in the various members of the bicycle frame, designating compressive stress by the +, and tensile stress by the − sign.

Member or Force.	First Condition. Fig. 2.	Second Condition. Fig. 4.	Third Condition. Fig. 5.	Fourth Condition. Fig. 6.
EB	+ **166.5**	+ 141.0	+ **166.5**	+ 139.0
CD	+ 47.0	+ 48.3	+ 62.1	+ **111.0**
DE	+ 57.5	+ 29.0	+ **59.0**	− **128.0**
EA	− **70.5**	− 60.0	− **70.5**	+ **330.0**
$A'D$	− 62.5	− 26.4	− 64.8	− **175.2**
DF	+ 22.5	+ **65.5**	+ 29.2	+ 53.0
GA'	+ 38.0	+ 71.7	+ 45.0	+ **95.5**
CF	45.2	25.0	59.7	106.0
FG	64.2	35.0	67.5	178.0
GH	19.0	10.0	7.8	72.0
AA'	− 4.5	− 30.2	− 2.5	+ 9.0

For each member, the stress in heavy-faced type is the greatest stress of the given character produced in the member by the conditions assumed. The magnitudes of the forces due to bending resistance are also given.

CONTINUED FRACTIONS.

George McC. Robson, M. A.

Origin—Reduction of Common Fractions—Principal and Intermediate Convergents. Application to Problems in Machine Design—Extraction of Roots. Ratio of Circumference of Circle to Diameter.

THE subject of this article is one of the most fascinating in the whole range of elementary mathematics, and is of considerable importance in the applications of mathematics to practical affairs.

Continued fractions were first recognized as part of the machinery of mathematics by Cataldi, an Italian mathematician, who published, in 1613, a treatise in which he used continued fractions to extract square roots approximately. The value of the new discovery, however, was not recognized until 1655, when it was further developed by Lord Brouncker, President of the Royal Society. Large contributions to the theory of continued fractions were made by Wallis in his Arithmetic (1656), and in his Algebra (1685).

An expression of the form

$$a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \cfrac{1}{a_4 +}}}$$

is called a *continued fraction.*

Any common fraction, in its lowest terms, can be reduced to a continued fraction; as an illustration, we shall take $\frac{67}{30}$.

We have, $\frac{67}{30} = 2 + \frac{7}{30}$. And,

$$\frac{7}{30} = \frac{7 \div 7}{30 \div 7} = \frac{1}{\frac{30}{7}} = \frac{1}{4 + \frac{2}{7}} =$$

$$\frac{1}{4 + \frac{2 \div 2}{7 \div 2}} = \frac{1}{4 + \frac{1}{\frac{7}{2}}} = \cfrac{1}{4 + \cfrac{1}{3 + \frac{1}{2}}}$$

Therefore, $$\frac{67}{30} = 2 + \cfrac{1}{4 + \cfrac{1}{3 + \frac{1}{2}}}$$

which is a continued fraction according to the definition.

We shall now compare the process of reducing a common fraction to a continued fraction with the operation for finding the

greatest common divisor (G. C. D.) of its denominator and numerator, remembering that, since the common fraction must be in its lowest terms, the G. C. D. will be unity. For example, suppose that

$$\frac{47}{14}=a_1+\cfrac{1}{a_2+\cfrac{1}{a_3+\cfrac{1}{a_4+}}}$$

The operation for finding the G. C. D. of 14 and 47 is

14) 47 (3 = 1st quotient.
 42
 5) 14 (2 = 2d quotient.
  10
  4) 5 (1 = 3d quotient.
   4
   1) 4 (4 = 4th quotient.
    4

With this we compare the reduction of $\frac{47}{14}$ to a continued fraction, which is as follows:

$$\frac{47}{14}=3+\frac{5}{14}=3+\frac{1}{\frac{14}{5}}=3+\frac{1}{2+\frac{4}{5}}=$$

$$3+\frac{1}{2+\frac{1}{\frac{5}{4}}}=3+\cfrac{1}{2+\cfrac{1}{1+\frac{1}{4}}}$$

Therefore,

$$\frac{47}{14}=a_1+\cfrac{1}{a_2+\cfrac{1}{a_3+\cfrac{1}{a_4+}}}=3+\cfrac{1}{2+\cfrac{1}{1+\frac{1}{4}}}$$

Hence,

$a_1=3=$ 1st quotient in operation for G. C. D.
$a_2=2=$ 2d quotient in operation for G. C. D.
$a_3=1=$ 3d quotient in operation for G. C. D.
$a_4=4=$ 4th quotient in operation for G. C. D.

We shall refer to a_1, a_2, a_3, a_4, etc. as the *first, second, third, fourth,* etc. *quotient.*

Rule.—If a common fraction $\frac{A}{B}$ *is converted into a continued fraction*

$$a_1+\cfrac{1}{a_2+\cfrac{1}{a_3+\cfrac{1}{a_4+}}}$$

then, a_1, a_2, a_3, a_4, *etc. are the successive quotients in process of finding G. C. D. of B and A. If* $\frac{A}{B}$ *is a proper fraction, the first quotient* a_1 *is zero.*

EXAMPLE.—Convert $\frac{13}{69}$ into a continued fraction.

SOLUTION.—

69) 13 (0 = 1st quotient $= a_1$.
 13) 69 (5 = 2d quotient $= a_2$.
  65
  4) 13 (3 = 3d quotient $= a_3$,
   12
   1) 4 (4 = 4th quotient $= a_4$.
    4

Therefore,

$$\frac{13}{69}=0+\cfrac{1}{5+\cfrac{1}{3+\frac{1}{4}}}=\cfrac{1}{5+\cfrac{1}{3+\frac{1}{4}}}$$

The series of quantities a_1, $a_1+\frac{1}{a_2}$,

$$a_1+\cfrac{1}{a_2+\cfrac{1}{a_3}}\qquad a_1+\cfrac{1}{a_2+\cfrac{1}{a_3+\cfrac{1}{a_4}}}$$

etc., are called the *principal convergents* to the continued fraction

$$a_1+\cfrac{1}{a_2+\cfrac{1}{a_3+\cfrac{1}{a_4+}}}$$

The principal convergents, when reduced to simple fractions, are denoted by

$$\frac{p_1}{q_1},\ \frac{p_2}{q_2},\ \frac{p_3}{q_3}\ldots\frac{p_n}{q_n}$$

By simplifying the convergents, we have,

1st convergent $=\frac{p_1}{q_1}=a_1=\frac{a_1}{1}$.

2d convergent $=\frac{p_2}{q_2}=a_1+\frac{1}{a_2}=\frac{a_1a_2+1}{a_2}$.

3d convergent $=\frac{p_3}{q_3}=a_1+\cfrac{1}{a_2+\cfrac{1}{a_3}}=$

$$\frac{(a_1a_2+1)a_3+a_1}{a_2a_3+1}$$

4th convergent $=\frac{p_4}{q_4}=a_1+\cfrac{1}{a_2+\cfrac{1}{a_3+\cfrac{1}{a_4}}}=$

$$\frac{(a_1a_2a_3+a_3+a_1)a_4+a_1a_2+1}{(a_2a_3+1)a_4+a_2}$$

and so on. It will be observed that these convergents are formed by the following rule:

Rule.—I. The numerator of any convergent is formed by multiplying the numerator of the preceding convergent by the corresponding quotient, and adding the numerator of the second preceding convergent.

II. The denominator of any convergent is formed by multiplying the denominator of the preceding convergent by the corresponding quotient and adding the denominator of the second preceding convergent.

The second part of this rule differs from the first part only by the substitution of the word "denominator" for the word "numerator." The rule is expressed in the following formulas:

$$p_n = a_n p_{n-1} + p_{n-2} \qquad (1)$$
$$q_n = a_n q_{n-1} + q_{n-2} \qquad (2)$$

A convenient form for the calculation of convergents is exhibited in the next example.

EXAMPLE.—Calculate the successive convergents to the continued fraction

$$2 + \cfrac{1}{4 + \cfrac{1}{3 + \cfrac{1}{2}}}$$

SOLUTION.—

No. of convergent			1	2	3	4
Quotient			2	4	3	2
Numerator	0	1	$2\times1+0$	$4\times2+1$	$3\times9+2$	$2\times29+9$
Denominator	1	0	$2\times0+1$	$4\times1+0$	$3\times4+1$	$2\times13+4$

Or,

No. of convergent			1	2	3	4
Quotient			2	4	3	2
Numerator	0	1	2	9	29	67
Denominator	1	0	1	4	13	30

In this form the first two columns are prefixed merely in order that the first two convergents may be formed in exactly the same way as the subsequent convergents. Hence, the required convergents are $\frac{2}{1}$, $\frac{9}{4}$, $\frac{29}{13}$, $\frac{67}{30}$. Ans.

0	1
1	0

We have already seen that this continued fraction arises from converting $\frac{67}{30}$, which is the last convergent, into a continued fraction. From this we draw the following conclusion: *The last convergent is the same as the common fraction from which the continued fraction is derived.* It is also important to notice that *each of the convergents is in its lowest terms.*

We refer the reader to any treatise on algebra for the proof of the very important property of any two consecutive convergents, which is expressed by the formula

$$p_n q_{n-1} - p_{n-1} q_n = \pm 1. \qquad (3)$$

The formula can be verified by applying it to the convergents in the last example, multiplying as indicated by the cross-lines.

$$\frac{2}{1} \times \frac{9}{4}, \quad \frac{9}{4} \times \frac{29}{13}, \quad \frac{29}{13} \times \frac{67}{30}$$

$$8 - 9 = -1, \qquad 117 - 116 = +1,$$
$$870 - 871 = -1.$$

Suppose we have a continued fraction

$$F = a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \cfrac{1}{a_4 +}}}$$

The first convergent a_1 is evidently less than F by the amount

$$\cfrac{1}{a_2 + \cfrac{1}{a_3 + \cfrac{1}{a_4 +}}}$$

The second convergent

$$a_1 + \frac{1}{a_2}, \text{ or } \frac{a_1 a_2 + 1}{a_2}$$

is greater than F, because the denominator a_2 is less than the whole denominator

$$\cfrac{1}{a_2 + \cfrac{1}{a_3 + \cfrac{1}{a_4}}}.$$

Thus, it can be shown that the *first, third, fifth, and all convergents of odd order are less than F; while the second, fourth, sixth, and all convergents of even order are greater than F*; also, that *any convergent is nearer to the true value of F than any previous convergent, or any other fraction whose denominator does not exceed the denominator of the convergent.* Further, that *the difference between the nth convergent $\frac{p_n}{q_n}$ and F is less than $\frac{1}{q_n q_{n+1}}$, and greater than $\frac{a_{n+2}}{q_n q_{n+2}}$.*

The principles just stated have many practical applications; thus, the ratio of the circumference of a circle to its diameter is

$$\pi = 3.14159265358 + = \frac{314{,}159{,}265{,}358}{100{,}000{,}000{,}000};$$

the successive quotients in finding the G. C. D. of the denominator and numerator of this fraction are 3, 7, 15, 1, 292, 1, 1. Hence,

$$\pi = 3 + \cfrac{1}{7 + \cfrac{1}{15 + \cfrac{1}{1 + \cfrac{1}{292 + \cfrac{1}{1 + \cfrac{1}{1 +}}}}}}$$

Calculating the convergents, we have,

n			1	2	3	4	5	6	7
a			3	7	15	1	292	1	1
p	0	1	3	22	333	355	103,993	104,348	208,341
q	1	0	1	7	106	113	33,102	33,215	66,317

Thus, we have the following approximate values of π:

$\frac{p_1}{q_1} = \frac{3}{1} = 3.$ (Too small.)

$\frac{p_2}{q_2} = \frac{22}{7} = 3.14285 +$ (Too large.)

$\frac{p_3}{q_3} = \frac{333}{106} = 3.141509 +$ (Too small.)

$\frac{p_4}{q_4} = \frac{355}{113} = 3.1415929 +$ (Too large.)

The second convergent $\frac{22}{7}$ is correct to two decimal places, which is sufficiently accurate for some purposes; this is the ratio that was found geometrically by Archimedes (B. C. 212). The fourth convergent $\frac{355}{113}$ is an excellent approximation, being correct to six decimal places. The error in taking the fourth convergent for π may be estimated thus:

$$\frac{1}{q_n\, q_{n+1}} > \text{error} > \frac{a_{n+2}}{q_n\, q_{n+2}}.$$

or, $$\frac{1}{113 \times 33{,}102} > \text{error} > \frac{1}{113 \times 33{,}215};$$

that is,

$$.0000002673 > \text{error} > .0000002665.$$

In fact we have,

$$\pi = 3.14159265358.$$

$$\frac{p_4}{q_4} = \frac{355}{113} = 3.14159292035.$$

Error in excess $= .00000026677.$

The fraction $\frac{355}{113}$ can be easily remembered, as it consists of the first three odd numbers, each of which is written twice. This approximation was first obtained by Peter Metius, of Holland, in the 16th century, who obtained it, however, by a happy guess; and, having no idea how excellent an approximation he had obtained, never published it. His son Adrian Metius published his father's discovery when he found how closely it agreed with the value of π calculated by later mathematicians.

The third convergent $\frac{333}{106}$ is never used as an approximate value of π, because it is not more convenient to use in calculations than the fourth convergent, and yet is not nearly so accurate.

To get a good approximation, it is advisable, when possible, to take a convergent that precedes a large quotient. Thus, in the example we have been considering, the third quotient, 15, and the fifth quotient, 292, are large; and we have seen that the second and the fourth convergent, which respectively precede these quotients, give useful approximations.

We have advanced a step, at least, towards the solution of the problem *to find the fraction whose denominator does not exceed a given integer D, and which most closely approximates (by excess or by defect) to a given fraction F.* This is a problem of great importance in many branches of pure and applied mathematics. Huygens investigated this problem when designing the toothed wheels of his planetarium, a machine which by the movements of its parts represents the motions and orbits of the planets; his description of the planetarium was published in 1682. The first complete solution of this problem was given in Wallis's Algebra. We have stated that any convergent $\frac{p_n}{q_n}$ is a closer approximation to the true value of the continued fraction than any other fraction whose denominator does not exceed q_n. Hence, we know that $\frac{22}{7}$ is nearer to the true value of π than any other fraction whose denominator does not exceed 7, and $\frac{333}{106}$ is nearer to the true value of π than any fraction whose denominator is less than 106. But suppose we require the closest approximation to π, whose denominator does not exceed 100; the denominator of the third convergent $\frac{333}{106}$ exceeds 100, and our proposition does not assert that the second convergent $\frac{22}{7}$ is nearer to π than any fraction whose denominator lies between 7 and 100; in fact, we have $\frac{311}{99}$ $(= 3.141414 +)$, which is nearer to π than $\frac{22}{7}$ $(= 3.14285 +)$. Thus, we see that the *principal convergents*, of which alone we have hitherto spoken, do not supply a complete solution of the problem we have just proposed. The missing link in our solution is supplied by the *intermediate convergents* which are defined as follows. In the series of fractions,

$$\frac{p_{n-2}}{q_{n-2}}, \frac{p_{n-2}+p_{n-1}}{q_{n-2}+q_{n-1}}, \frac{p_{n-2}+2p_{n-1}}{q_{n-2}+2q_{n-1}},$$
$$\frac{p_{n-2}+3p_{n-1}}{p_{n-2}+3p_{n-1}}, \ldots \frac{p_{n-2}+a_n p_{n-1}}{q_{n-2}+a_n q_{n-1}} \left(= \frac{p_n}{q_n}\right),$$

the first $\frac{p_{n-2}}{q_{n-2}}$ and the last

$$\frac{p_{n-2}+a_n p_{n-1}}{q_{n-2}+a_n q_{n-1}} \left(= \frac{p_n}{q_n}\right)$$

have been called principal convergents; the others are called *intermediate convergents.*

Every fraction, proper or improper, is greater than $\frac{0}{1}$ or 0, and less than $\frac{1}{0}$, or infinity; hence, $\frac{0}{1}$ and $\frac{1}{0}$ may be regarded as principal convergents to any continued fraction, and are denoted, respectively, by

$$\frac{p_{-1}}{q_{-1}} \text{ and } \frac{p_0}{q_0}.$$

If we take all the principal convergents of odd order with their intermediates, and form the series

$$\frac{0}{1} \ldots \frac{p_1}{q_1} \ldots \frac{p_3}{q_3} \ldots \frac{p_5}{q_5}; \qquad (4)$$

and also the principal convergents of even order with their intermediates, and form the series

$$\frac{1}{0} \ldots \frac{p_2}{q_2} \ldots \frac{p_4}{q_4} \ldots \frac{p_6}{q_6}; \qquad (5)$$

then (4) *is a series of increasing fractions, with increasing denominators, which continually approach to the true value of the continued fraction; and* (5) *is a series of decreasing fractions, with increasing denominators, which continually approach to the true value of the continued fraction.*

We can now state the solution of the problem to find the fraction whose denominator is not greater than D and which most closely approximates to a given fraction F. *Convert F into a continued fraction, and form the two series* (4) *and* (5), *and from them select the fraction whose denominator, not exceeding D, is nearest to D.*

Applying this rule to π, whose principal convergents we have calculated, we get the following two series of approximate values of π:

$$\tfrac{0}{1},\ \tfrac{1}{1},\ \tfrac{2}{1},\ \tfrac{3}{1},\ \tfrac{25}{8},\ \tfrac{47}{15},\ \tfrac{69}{22},\ \tfrac{91}{29},\ \tfrac{113}{36},\ \tfrac{135}{43},$$

$$\tfrac{157}{50},\ \tfrac{179}{57},\ \tfrac{201}{64},\ \tfrac{223}{71},\ \tfrac{245}{78},$$

$$\tfrac{267}{85},\ \tfrac{289}{92},\ \tfrac{311}{99},\ \tfrac{333}{106},$$

$$\tfrac{688}{219},\ \tfrac{1043}{332},\ \text{etc.} \qquad (4')$$

$$\tfrac{1}{0},\ \tfrac{4}{1},\ \tfrac{7}{2},\ \tfrac{10}{3},\ \tfrac{13}{4},\ \tfrac{16}{5},\ \tfrac{19}{6},\ \tfrac{22}{7},\ \tfrac{355}{113},\ \text{etc.} \qquad (5')$$

The fractions in (4′) form an increasing series, which continually approach more and more nearly to π; the fractions in (5′) form a decreasing series, which likewise approach to π. It is impossible to insert between two consecutive fractions of either series another fraction, whose denominator is less than the greater of the denominators of these two fractions. Hence, the fraction, with denominator less than 100, which approximates most closely, by defect, to π, is $\frac{311}{99}$; and the closest in excess is $\frac{22}{7}$.

As an example of the practical application of these principles, suppose that, in designing a machine it is necessary, in order to fulfil certain conditions, that one shaft should drive another in the velocity ratio of 4.4513 to 1. How nearly can we satisfy this requirement, if we are debarred from using any gear with more than 300 teeth? Convert 4.4513, or $\frac{44513}{10000}$, into a continued fraction, and calculate the principal convergents, as shown in the annexed form.

n	−1	0	1	2	3	4	5	6	7	8	9	10	11	12
a			4	2	4	1	1	1	2	1	2	7	1	3
p	0	1	4	9	40	49	89	138	365	503	1,371	10,100	11,471	44,513
q	1	0	1	2	9	11	20	31	82	113	308	2,269	2,577	10,000

Since we cannot use a gear with more than 300 teeth, the best approximation given by any principal convergent is $\frac{p_6}{q_6} = \frac{138}{31} =$ 4.45161+, which differs from the required ratio by .00031. We might also take the intermediate convergent

$$\frac{p_5 + p_6}{q_5 + q_6} = \frac{227}{51} = 4.45098,$$

which differs from the required ratio by .00032.

As an example of the application of continued fractions to the extraction of square roots, for which purpose they were originally employed, we shall reduce $\sqrt{3}$ to a continued fraction. The greatest integer in $\sqrt{3}$ is 1; let x denote the sum of these two quantities.

Then, $$x = 1 + \sqrt{3}. \qquad (a)$$

Transposing and squaring,

$$x^2 - 2x + 1 = 3.$$

Transposing and dividing by x,

$$x = 2 + \frac{2}{x}. \qquad (b)$$

Whence, $$x = 2 + \frac{1}{\frac{1}{2}x}. \qquad (c)$$

From (b), we have

$$\tfrac{1}{2}x = 1 + \frac{1}{x}. \qquad (d)$$

In the second member of (c), we can sub-

stitute the value of $\frac{1}{2}x$ given by (d); hence,

$$x = 2 + \cfrac{1}{1 + \cfrac{1}{x}} \qquad (e)$$

In the second member of (e), we can substitute for x the value $2 + \cfrac{1}{1+\cfrac{1}{x}}$, getting

$$x = 2 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{1 + \cfrac{1}{x}}}}.$$

Proceeding in this way, we get

$$x = 2 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{1 + \cfrac{1}{2 +}}}} \qquad (f)$$

Whence,

$$x - 1 = \sqrt{3} = 1 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{1 + \cfrac{1}{2 +}}}} \qquad (g)$$

By calculating the successive convergents to (g), we get a series of approximations, more and more exact, to $\sqrt{3}$; this method of obtaining roots is, however, of historic interest merely, since much more expeditious methods of root extraction are known. In (f) it will be observed that the quotients 2 and 1 recur, and the number of quotients is infinite; such a fraction is called a *recurring continued fraction*. Every quadratic surd is equivalent to a recurring continued fraction, and every recurring continued fraction is equivalent to a quadratic surd.

The method of approximation by continued fractions possesses two advantages which are of fundamental importance in any system of numerical calculations; namely, first, it furnishes a regular series of approximations to the quantity to be evaluated, which continually increase in exactness; second, the error of each successive approximation can be readily estimated.

Continued fractions are of extensive application in the solution of indeterminate equations, and in the theory of numbers; and supply a very elegant method of proving that π, π^2, and any commensurable power of e (the base of the natural system of logarithms) are incommensurable quantities. They are also useful in solving the problems which arise in rectifying the calendar, in calculating eclipses, and in constructing mortality tables.

THE MOTIVE FORCE IN HOT-WATER CIRCULATION.

W. M. Brown.

CLOSED AND OPEN SYSTEMS OF HEATING—THEIR RESPECTIVE ADVANTAGES—THE DANGER OF USING SHUNTS—A SINGLE PINE SHAVING MAKES A HEATING PLANT INOPERATIVE.

THE motive force in hot-water circulating apparatus is one of the subjects that should be well understood by the student and practitioner of artificial heating. Failure to comprehend this most vital point has caused many failures in practice. However well the boiler may be adapted to its work, or the radiating surface proportioned to the heating surface, if the constructor sets up the apparatus with the idea that he has the same motive force as in a steam-heating plant, he will naturally neglect the little things that make success in a hot-water circulating system possible. How much force have we that can be applied to the moving of the body of water in a hot-water circulating apparatus? This is the question to be discussed here, and, in part at least, illustrated.

In Fig. 1, let a represent a glass boiler, b a glass stand pipe, c and d glass pipes connecting the boiler and stand pipe. The boiler is 2 feet in height and 18 inches in diameter, the stand pipe has the same height and is 8 inches in diameter, and pipes c and d are 4 inches in diameter. The water in boiler a is heated to 200 degrees F. It returns to the boiler through pipe d at a temperature of 192 degrees F., having lost 8 degrees of its initial heat. The system shown in Fig. 1 may be considered as of the high-pressure variety. When the water in

the boiler is heated to the point indicated, some force acts to cause the outflow from the boiler to the stand pipe, and this force will be 153 grains, or about ⅓ of an ounce. Supposing this apparatus to have 100 yards of piping, 4 inches in diameter, and the boiler to contain 30 gallons, there will be 226 gallons of water in the whole apparatus to be circulated, or moved, through the piping and boiler. This amount of water weighs nearly 1,900 pounds, and must be kept moving by a force of only ⅓ of an ounce. Concerning the sizes of piping, while it is true that the motive force increases with the size of the pipe, i. e., the motive force in a pipe 4 inches in diameter would be four times that in a pipe 2 inches in diameter, yet it must be remembered that the 4-inch piping contains four times as much water to be moved as the 2-inch pipe, so that the force exerted, and the water it is exerted upon (in other words, the power and the resistance) are relatively the same. It is, therefore, a mistake to suppose that by increasing the size of the pipe we obtain an increase of motive force with which to overcome faults in piping, or such resistances as arise from obstructions in the form of foreign matter. Every increase in the size of pipe means an increase in the quantity of water to be moved, and there is, therefore, no motive force to be wasted in *any* size of piping. However perfectly the piping is proportioned and run, the margin in motive force is so narrow that extremely slight obstructions will render the apparatus practically inoperative. In a hot-water heating plant set up by the writer with the greatest of pains, and which should have worked perfectly, the circulation was found to be so sluggish as to render the apparatus practically worthless. On investigation, a curled pine shaving was discovered in the piping, and its convolutions were found to press together, or close, on the slightest movement of the water, thus forming a seal in the pipe. Had this occurred in a steam-heating plant, it is probable that the steam would have carried the shaving along until it lodged against a valve or in a bend in the pipe, and would have passed it after it had securely lodged; but with ⅓ of an ounce pressure in the water-circulating plant, the shaving was immovable, and acted as a seal in the pipe. This incident is mentioned to emphasize the fact that there is no motive force to spare in a hot-water circulating apparatus.

FIG. 1.

There are two so called systems of hot-water heating, viz.: the closed, and the open, called also the high-pressure, and the low-pressure, systems. Fig. 1 illustrates a closed system, in which the contained water is not open to the atmosphere, and may be heated to any desired temperature. Fig. 2 illustrates an open, or low-pressure, system, wherein h is the boiler, i the piping, and j an open tank, so arranged that the heated water passes directly upwards from the boiler to the tank, and thence, flowing downwards through the distributing pipes, returns to the boiler. In the apparatus, the temperature of the water in the tank will not rise to over 212 degrees F., and consequently no pressure will be exerted in the piping, other than that due to the weight of the water. The question at once suggests itself—which of these two systems is preferable? Upon this point the doctors disagree. For all ordinary purposes, the writer's preference is for the low-pressure apparatus, one reason being that the piping and radiators never get so heated as to scorch dust and other matter that may collect on them, and, therefore, create no disagreeable odors. The writer has operated high-pressure apparatus in which the heat was sufficient to scorch lint and like matter lodged on the pipes, thus causing a disagreeable smell. Leaks are also more liable to occur, and careful provision must be made to prevent air being confined in the pipes. When an open system is properly set up, there will be no trouble with confined air in the pipes or radiators; wherever it does exist, however, the piping might as well be plugged with wooden plugs

well driven home. For dwelling-house hot-water heating there is no possible excuse for departing from the open, or low-pressure, system, as there is nothing gained by using the high-pressure-system. All that is needed is a sufficient flow of a sufficient body of water to carry the heat to the radiators, where it will be thrown into the surrounding atmosphere to warm the house. In order to take all the advantage possible from the small motive force, we have, wherever it was possible to do so, constructed hot-water heating apparatus on the plan of Fig. 2. As there shown, only two radiators are connected with the system, but any desired number can be used. In such a system the motive force acts vertically, the heated currents of water rising directly from the boiler to the tank, preferably through a riser having neither bends nor elbows.

This can not always be accomplished, especially where the apparatus is set up in

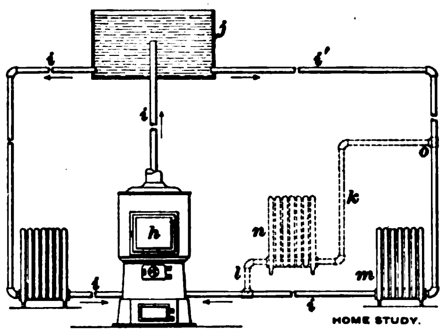


FIG. 2.

a building already otherwise completed, in which case it may be impossible to run the riser without an elbow or elbows. But when the apparatus is to be put in a building during its construction, it is usually not difficult to find a way to accomplish this end. By so doing there is never any difficulty with the circulation, provided the piping is not clogged with foreign matter. It will be seen that each radiator has its inflow and outflow pipes entirely separated from the rest of the piping, and communicating directly with the tank and the boiler.

The dotted lines at *k*, *n*, and *l* show an attempt to supply a radiator by a branch-pipe *o*. This is a mistake that is often made in piping for hot water. Water circulating in a hot-water apparatus will, like water under other conditions, seek the easiest and least obstructive paths. In Fig. 2, radiator *m* would have a good circulation, while radiator *n* would have a very slow circulation, if any at all, and the swifter the circulation in pipe *i'* and radiator *m*, the worse for radiator *n*. The reason for this is that the downward drop or flow of the water in pipe *i'* is perfectly natural and meets with no obstruction, but at the point *o* an attempt is made to divert the flow from its natural channel. As it is not as easy for the water to flow through pipe *k* as through pipe *i'*, the consequence is, that when the point *o* is reached, the downward current refuses to be switched off into pipe *k*, as it finds it easier to continue its direct downward course, and as a result pipe *k* gets little or no heated water. It is often very preplexing to account for the want of circulation of water in pipes that are branched from the main piping. To cure this evil, all sorts of expedients are sometimes resorted to; this simply emphasizes the fact that wherever it is possible to get a direct flow from the tank *j* to a radiator and then to the boiler, it is better to do so. The main objection, and the only one of any force, against giving each radiator its separate inflow and outflow pipes is the extra cost of piping, but in ordinary house warming this is a very small matter compared with the difficulty of providing shunts, bypasses, and other current-destroying devices that are sometimes used. It is not intended to intimate that shunting can not be successfully accomplished under certain conditions, but the point sought to be made prominent is that, the motive force being so small, it is the best practice, wherever it can be carried out, to have the circulation as direct, or with as little shunting, as possible. To exemplify this, if pipe *i'*, Fig. 2, were doubled in diameter from the tank *j* to the point *o*, so as to contain sufficient water, the current would more easily and surely divide at that point. Part would flow through pipe *k* and radiator *n*, for immediately below point *o* the water would meet a smaller pipe to carry it to radiator *m*. It would therefore receive a check, be turned towards pipe *k* and enter it, assuming, of course, that pipe *k* and the one feeding the radiator *m* are of the same capacity. Yet a very slight obstruction in the pipe at point *o* would destroy the desired flow by changing its direction from one pipe to the other. With the closed system of hot-water heating, the writer has seen many cases in which several radiators in the system received no flow whatever, all going to those that were connected directly with the boiler without

being shunted. In such cases, it requires better judgment and more patience to discover the cause of the trouble than to remedy it after discovery. Yet the foundation of any such difficulty may be in the small motive force incident to all hot-water circulating devices. This being the fact, it behooves the beginner never to lose sight of the small amount of force he has at command with which to accomplish the desired end. In order to better study this most interesting question, let the reader construct an apparatus such as that shown in Fig. 1, entirely of glass. Have the boiler 2 feet high and 18 inches in diameter; the stand pipe *b* 8 inches in diameter, and pipes *c* and *d*, 2 inches in diameter. Such sizes in glass can be easily obtained. If desired, the sizes can be less, as there is no particular point gained by using those given. When the apparatus is prepared, obtain some amber by coarsely granulating an old amber pipe-stem or mouthpiece. This is probably the cheapest way to obtain the amber. The reason for using amber is that its specific gravity is such that it will lie in suspension in water. Procure either well filtered water or that obtained from condensed steam, in order to have it perfectly clear. Of course, the amber must also be thoroughly cleansed from all coloring matter before using. Fill the apparatus with this water and stir in the granulated amber. To avoid danger, construct the apparatus as an open, or low-pressure system, which may be done by simply leaving the top of the boiler open. When a spirit lamp is applied to the bottom of the boiler, every current arising from the heat will be plainly seen, and can be followed throughout the entire apparatus. By inserting obstructions, such as shavings, pieces of rag, and like foreign matter, in the mouths of the pipes *c* and *d*, the retardation of the currents can be easily observed. A curled shaving placed in the mouth of the pipe *c* where it leaves the boiler, so that the shaving will lie perfectly free and endwise in the pipe, will provide an entertaining and instructive lesson to the student. He will find that the swiftest water in pipe *c* lies against, and moves along, the top surface, and that in pipe *d* the whole body of the water moves more nearly at a uniform rate. If he should construct an apparatus like that shown in Fig. 2, he would find the water in the vertical riser *i* moving swiftest in the center of the pipe, while it would seem to cling to the sides. Ocular demonstration of obstructions in such systems of piping as are afforded by an apparatus constructed of glass will go a long way towards teaching the reader of this article the necessity of taking the greatest care of his small stock of motive force in a hot-water circulating apparatus.

THE STANDARD YARD.

George McC. Robson, M. A.

Ancient Measures—Difficulty of Constructing a Reliable Standard—British Standard—United States Standard—Metric System—Natural Units.

IN THE most primitive state of society, men must have had some way of estimating distances; probably the earliest unit for measuring long distances was the length of a day's journey, the distance between two places being expressed as so many days' journey; while short distances were measured by the breadth of the finger or the length of the forearm. A finger breadth was called a digit; the Roman digit was about .73 of an English inch. A cubit was the length of the arm from the elbow to the end of the middle finger.

Such units were indefinite and unsatisfactory—a fixed and invariable unit of measurement is indispensable in science, in mechanical and decorative art, and in commerce; and wherever architectural and engineering works were undertaken some artificial unit had to be adopted. These artificial units generally received the names of the older units, which were derived from parts of the body. The oldest artificial unit of weight or length of which we have any record is the royal Egyptian cubit, which was used in the construction of the pyramids perhaps 3,500 years before the Christian era. From measuring rods found in the tombs of

Egypt, the Egyptian cubit is known to have been equal to 20.64 inches. The Roman cubit was equal to 17.4 inches. These are the only cubits whose lengths are undisputed.

The importance of having standard units of measurement has been recognized in every civilized community, and it has been part of the public policy to establish such standards. Unfortunately in the past, the regulation of this matter was in the hands of the local magistracy ; and, in the last century, every town in Europe had independent standards. This multiplicity of measures caused endless confusion and great embarrassment to commerce ; to augment this confusion, the same name was frequently employed for different units ; thus for example, from Norway to Spain the linear unit was the foot, but no two loaclities had the same foot. The foot as a linear unit probably originated in Greece, where the Olympic foot is said to have been the length of the foot of Hercules.

Before the Norman Conquest, the British yard was equal to 39.6 of our inches ; in 1101 A. D. it was reduced to the length of the arm of Henry I ; and at a late period an artificial standard was deposited in the Exchequer. The earliest legislation on the subject is in the 25th chapter of the reaffirmation of the Magna Charta under Henry III, in the year 1225, and simply declares that the standards must be uniform throughout the realm. The artificial standard deposited in the Exchequer was ill preserved, and soon became so unreliable that a statute was enacted in 1324 to establish a uniform linear standard ; this statute declares that an inch shall be the length of three barleycorns, round and dry, laid end to end. No standard yard is known to have been constructed on this basis. The oldest standard yard in existence dates from the reign of Henry VII, but it has long been disused. There is also extant a yard of the reign of Queen Elizabeth ; it was very poorly constructed and has been broken and jointed in the most bungling manner ; nevertheless, till the year 1826, it was the legal standard.

During the 18th century, attempts were made to get an exact and reliable standard yard. A committee of the Royal Society, in 1742, examined and compared all existing standards, and selected one found in the Tower of London. Mr. George Graham, an eminent clockmaker, constructed a model of this yard, and determined the length of the seconds-pendulum in London to be 39.14 inches. In 1758 a committee of the House of Commons had a copy of Graham's yard made by Bird ; and in 1760 another committee authorized Bird to make a second copy, which was marked "Standard of 1760."

In 1818 a Royal Commission under Sir George Banks, President of the Royal Society, examined the British standards. The recommendations of this commission were embodied in a statute which went into effect on January 1st, 1826. The statute provides that the standard yard shall be the length, at 62° Fahrenheit, of the straight line between the centers of the two points in the gold plugs in the brass rod then in the custody of the Clerk of the House of Commons, on which were engraved the words "Standard Yard, 1760." In case the standard is lost or destroyed, the act provides that it shall be restored by reference to the length of the pendulum which beats seconds of mean solar time, in the latitude of London, at sea level, in a vacuum ; the length of this pendulum is declared by the statute to be 39.1393 inches. This determination of the length of the seconds-pendulum was obtained by Captain Henry Kater from a series of experiments with a reversible pendulum ; these experiments will be described in a future article.

The Houses of Parliament were destroyed by fire on October 16, 1834 ; the bar of 1760 was recovered, but one of its gold plugs was missing, and it was otherwise injured. A commission was appointed to report to the government on the best method of restoring the standards. In 1841 this commission reported that the definition by which the standard yard is declared to be a certain brass rod is the best possible definition, and reported against the pendulum method of fixing the standard, on the ground that the original determination of the length of the seconds-pendulum was inaccurate. The commission stated that there existed several measures which had been carefully compared with the original standard yard, and that by use of these the standard yard could be restored without sensible error. The commission reported in favor of adopting as standard the length of a yard belonging to the Astronomical Society, which had been recognized by the Standards Commission of 1818. From this, the present Imperial Standard Yard was constructed, and became the legal standard in 1855. It is a bronze bar, 38 inches long ; the yard is defined by two parallel lines, 36 inches apart, cut on gold plugs, which are sunk in holes to the center of the bar. When in use, the bar rests on a frame, which supports it at 8 points, 4.78 inches apart, on rollers which

divide the pressure equally. For less critical purposes, measuring bars should be supported at two points 21 per cent. of the whole length from the ends, in order to equalize the strain in the fibers, and make the distortion minimum. Other yards are compared with the standard by means of two micrometer microscopes, with parallel axes which are fixed on a massive stand. The limit of error in the Standards department, for one observation, is 100,000th of an inch. A standard of this kind, where the length is marked by parallel lines, is called a *line standard;* there is another type of standard known as an *end standard,* in which the length is defined by two points in parallel surfaces. In end standards, comparisons can only be made by contact. For all accurate purposes, line standards are employed. Comparisons with the Imperial standard yard are made gratuitously, as a matter of courtesy, by the officials of the department. For public use there are a series of end standards on the outer wall of Greenwich Observatory. One of these is 100 feet long, and the department has determined the errors:

At	0	10	20	30	40	50	feet.
Error,	0	—.007	—.019	—.022	—.015	—.008	inch.
At		60	70	80	90	100	feet.
Error,		—.007	+.011	+.021	+.17	—.008	inch.

In early colonial times, many of the colonial legislatures adopted the British standards, though they did not always specifically designate them by name. Though the Constitution authorizes Congress to fix the standards of measure, there has been little legislation on the subject, and Congress has never definitely exercised this power. Owing to the failure of Congress to act, it became necessary for the executive branch of the government to obtain standards. In 1814 the Coast and Geodetic Survey obtained a standard made by Troughton of London; it is 82 inches long, and the part between the 27th and the 63d division was adopted as the standard yard. An examination, in 1830, of the measures in the various custom houses throughout the country disclosed serious discrepancies; for the sake of uniformity the treasury department adopted the Troughton scale, and deposited copies of it with the governor of each state.

After the adoption of the present Imperial standards in England, accurate copies of them were received at the office of Weights and Measures in Washington, and the British yard is commonly regarded as the standard of the United States.

A new system of measures, known as the metric system, originated in France. Five eminent mathematicians—Borda, Condorcet, Lagrange, Laplace, and Monge—determined the length of the quadrant of the meridian which passes through Paris. One ten-millionth of this length was taken as the linear standard, and was called a *meter.* According to their determination, a meter is equal to 39.37079 inches. Sir John Herschel and others have shown that the measurement of the earth quadrant on which the meter is based was inaccurate. It is manifest, however, that the length of the legal meter could not be changed with every improvement in the measurement of the earth; practically, therefore, a meter is a certain length preserved in Paris.

In 1866, Congress authorized the use of the metric system in this country, and directed that the new five-cent piece should be one-fiftieth of a meter in diameter; it was, however, found impossible to carry out this direction. This Act of Congress fixes the relation between the meter and the yard with extreme accuracy.

In 1875, an International Metric Convention was agreed upon by the principal governments of the world to prepare international standards of weights and measures. Copies of these were distributed, by lot, among the contributing governments in 1889. The United States got meters Nos. 21 and 27. The Secretary of the Treasury in 1893 formally approved of the recommendation of the Superintendent of Weights and Measures to make the meter the fundamental unit and to derive the yard from it, in accordance with the Act of 1866. Therefore, as far as the action of the Treasury goes, the yard is defined as $\frac{36}{39.37043}$ of a meter.

Many attempts have been made to fix what is called a *natural* unit of length. Thus, it has been proposed to define an inch as a certain submultiple of the polar diameter of the earth; to define the yard by reference to the seconds-pendulum; and to define the meter as a submultiple of an earth quadrant. It has even been proposed to adopt as a unit the wave length of a particular kind of homogeneous light. All these so-called natural units have been abandoned, as was pointed out in the cases of the meter and the yard, on account of the difficulty of fixing any of these lengths with sufficient accuracy. It seems a very simple matter to establish a standard of linear measure; but a little reflection will show that this seeming simplicity is delusive, and as an historical fact

this problem has occupied the attention of such distinguished scientists as Kater, Young, Playfair, Airy, Herschel, and Lubbock in England, and Laplace, Lagrange, and Bessel on the continent of Europe. There is now a consensus of opinion among scientific men in favor of the metric system as adopted by the International Metric Convention, and this system is coming more and more into use every year.

AMSLER'S POLAR PLANIMETER.*

Antonio Llano.

GENERAL DEMONSTRATION OF THE PRINCIPLES OF THE PLANIMETER—PRACTICAL DIRECTIONS FOR THE USE OF THE INSTRUMENT.

IN THE foregoing explanations we have supposed the angle x, Fig. 2, to be "infinitely small," or so small that its arc may be taken to coincide with either its chord or its tangent. These expressions are not to be taken literally, for no arc, however small, can coincide with its chord; but, as the error arising from this assumption may be made smaller than any quantity, by constantly decreasing the angle x, it is easy to show that ultimately there is no error at all. This will be better understood when we come to the consideration of areas in general. We shall assume the correctness of the theorem given above, and proceed to the case of any area, such as $D D_1 H_1 H$, Fig. 3, bounded by two concentric circular arcs.

If we divide this area into very small or "infinitesimal" areas, by means of radii $e h_1$, $e h_2$, etc., we may apply our rule to each of the elementary areas $D h_1$, $d_1 h_2$, $d_2 h_3$, etc. (Each area is denoted by the letters at two opposite vertexes.) Suppose the anchor point of the planimeter to be fixed at e. If we move the pointer from h_1 to H, then from H to D along $H D$, then along the arc $D d_1$, and then back to h_1, the rolling of the wheel will be proportional to the area $D h_1$ (or area $D h_1 = h\ W$).

If, now, we raise the wheel, so as to prevent its rolling while the pointer is moved to h_2, and, letting it down again, move the pointer around $h_2 h_1 d_1 d_2$, the additional rolling will be equal to the first, and, therefore, the total area $D h_2$ will be given by h times the total rolling. Proceeding in the same way with the other areas, we shall obtain the total area $D H_1$ by multiplying the total rolling of the wheel by h. But we obtain the same result if we move the pointer continuously from H_1 to H, from H to D, from D to D_1, and from D_1 back to H_1; for it will be readily seen that, by moving the pointer over each small area separately, all the radial motions counteract one another in pairs, and the only motions of the pointer that affect the total rolling of the wheel are the motions along $h_1 H$ and $D d_1$, $h_2 h_1$ and $d_1 d_2$, etc., whose combined effect is obviously the same as if the pointer had been moved continuously over $H_1 H$ and $D D_1$. If we denote by W the total rolling of the wheel, and by A the area $D H_1$ we shall have

$$A = h\ W.$$

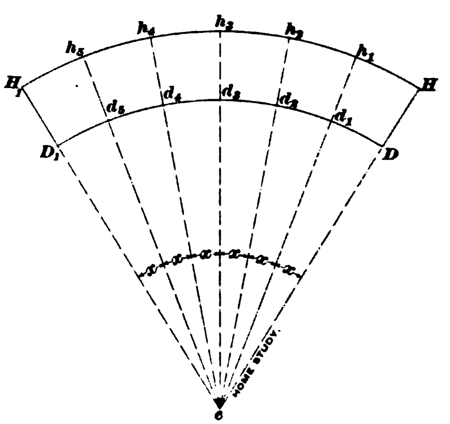


FIG. 3.

In Fig. 4, we have an area $d_0 d_0' r_0 r_0'$, bounded by four straight lines, e being the point of intersection of the two opposite sides $d_0' r_0$ and $d_0 r_0'$. Describe the two arcs $d_0 m_0$, $r_0 n_0$, with center e and radii $e d_0$ and $e r_0$. Let the anchor point of the planimeter be fixed at e, and the pointer placed at d_0. If the pointer is moved along the arc $d_0 m_0$, then down the radius $m_0 e$ to r_0, then along the arc $r_0 n_0$, and

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up the radius ed_0 back to d_0, the rolling of the wheel (multiplied, of course, by the constant h) will measure the area $d_0 m_0 r_0 n_0$, which differs from the required area by the sum of the areas $d_0 m_0 d_0'$ and $r_0 n_0 r_0'$.

Now draw the bisector ed_1 of the angle $d_0 e d_0'$, and the arcs $d_1 m_1'$ and $r_1 n_1'$, with center e and radii ed_1 and er_1. If the pointer is moved from d_0 to m_1, on the arc $d_0 m_0$, then up the radius ed_1 to d_1, then along the arc $d_1 m_1'$ to m_1', down the radius $d_0'e$ to r_0, then over the outline $r_0 n_1 r_1 n_1' d_0$, back to d_0, the rolling of the wheel due to radial motions of the pointer will be zero, for the latter motions balance each other in pairs; and the resultant rolling will measure the sum of the areas $d_0 m_1 r_1 n_1'$ and $d_1 m_1' r_0 n_1$, whose difference from the required area is less than before by the sum of the areas $d_1 m_1' m_0 m_1$ and $r_1 n_1' n_0 n_1$. That is, in the present case, we have approached the required area more closely than in the preceding case, by including the areas $d_1 m_1' m_0 m_1$ and $r_1 n_1' n_0 n_1$.

Next draw the bisector ed_2' of angle $d_1 e d_0'$, and the bisector ed_2 of angle $d_0 e d_1$, and describe the arcs $d_2 m_3$ and $d_2' m_3'$, $r_2 n_3$ and $r_2' n_3'$. If now the pointer is moved around the figure $d_0 m_2 d_2 m_3 d_1 m_2' d_2' m_3' r_0 n_2 r_2 n_3 r_1 n_2' r_2' n_3' d_0$, in the direction indicated by the order of the letters, the rolling of the wheel will measure the sum of the areas $d_0 r_2'$, $d_2 r_1$, $d_1 r_2$, and $d_2' r_0$ (denoting, as before, each quadrilateral area by the letters at two opposite vertexes), whose difference from the required area is much less than in the preceding case. We might next bisect each of the four angles at e, then each of the eight angles thus formed, etc., and show that the resulting area would be closer and closer to the required area $d_0 d_0' r_0 r_0'$; but this is not necessary, as it is not these approximations we are after, but the exact area, or the "limit" that the approximate values constantly approach.

Two things will be noticed with regard to the operations we have just described:

First, the sum of the trapezoidal curved areas formed by the successive arcs and the corresponding differences between the radii is never equal to the total area $d_0 d_0' r_0 r_0'$; but, by continued divisions and subdivisions of the central angles, we can make the sum approach the total area $d_0 d_0' r_0 r_0'$ as closely as we wish. In other words, the difference between the total area and the sum of the trapezoidal areas may be made *smaller than any given quantity*. This is what is meant by saying that the total area is the *limit* of the sum of the curved trapezoidal areas.

Second, the rolling of the wheel due to the motion of the pointer over the arc $d_0 m_0$ is evidently not the same as if the pointer had been moved along the straight line $d_0 d_0'$; for, in the first case, the angle a_0 remains constant, and in the second case the angle continuously changes from its original value a_0 to a final value a_0' (not shown), when the pointer is at d_0'. When, however, we move the pointer from d_0 to m_1, then to d_1, and along the arc $d_1 m_1'$ to m_1', we take into account not only the initial value a_0 of the

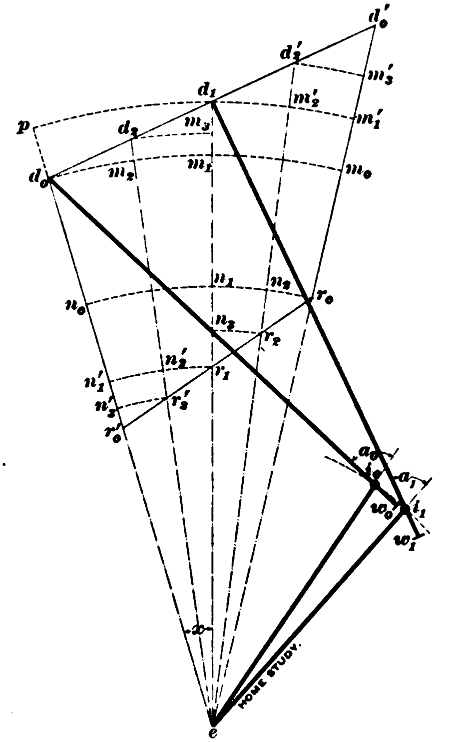


FIG. 4.

angle a (the letter a denoting, in general, the angle between the two arms, as a_0, a_1, etc.) but also one of its intermediate values, a_1, corresponding to the position d_1 of the pointer, the variation from a_0 to a_1 taking place while the pointer is moved from m_1 to d_1. When the pointer is moved over $d_0 m_2 d_2 m_3 d_1 m_2' d_2' m_3'$, the intermediate values a_2, a_1, a_2' of a are taken into account, and the transition from one to the other (as from a_0 to a_2) is accomplished by radial motion of the pointer (as from m_2 to d_2).

It is easy to see that, in proportion as the number of central angles is increased, the

transition from one value of a to the next is more and more gradual, and the sum of the radial motions approaches nearer and nearer to $m_0 d_0'$. Thus, when the pointer moves from d_0 to m_0, no radial motion takes place; when it moves over $d_0 m_1 d_1 m_1'$, the radial motion is $m_1 d_1 = m_0 m_1'$; when it moves over $d_0 m_2 d_2 m_3 d_1 m_3' d_2' m_3'$, the radial motion is $m_2 d_2 + m_3 d_1 + m_2' d_2' = m_0 m_3'$, etc. It is also obvious that the difference $m_3' d_0'$ may be reduced as much as we please.

Now, the motion of the pointer along $d_0 d_0'$ may be considered as made up of a combination of two motions. First, a motion of the pointer along the radius (since its distance from the center is constantly changing); and this motion, by constantly changing the angle a (as from a_0 *gradually* to a_1), causes a certain amount of rolling in the wheel. Second, a motion of rotation of the pointer about e, producing a rolling of the wheel depending upon the value of a at every instant. The total rolling due to radial motion is evidently equivalent to the rolling due to the motion of the pointer from m_0 to d_0', for this is the total change in the length of the radius; and, as we have seen that the sum of the successive radial motions $m_2 d_2$, $m_3 d_1$, etc. can be made as close to $m_0 d_0'$ as we please, we may say that the rolling of the wheel due to the motion of the pointer along $m_0 d_0'$ is the limit of the sum of the rollings due to the successive radial motions $m_2 d_2$, etc. Of course, when the pointer is moved from m_3' to m_0, all the preceding radial motions are counteracted; it is, however, necessary to take the latter into account as components of the motion of the pointer along $d_0 d_0'$ only, when the latter motion is to be studied by itself.

As to the motion of rotation of the pointer about e, notice that, if we pass from d_0 to d_1 over the outline $d_0 m_1 d_1$, the rolling of the wheel due to the rotation of the pointer will be $R_0 = (k \cos a_0 - l)x'$, where x' is the central angle $d_0 e d_1$ reduced to circular measure [see formula (4)]. If, on the contrary, we first change the angle a from a_0 to a_1, by moving the pointer along $e d_0$ to p, and then move the pointer over the arc $p d_1$, the rolling of the wheel due to the rotation $p d_1$ will be $R_1 = (k \cos a_1 - l)x'$. In the present case, a_0 is greater than a_1, and therefore $\cos a_0$ is less than $\cos a_1$; consequently, R_0 is less than R_1. As, when the pointer is moved along $d_0 d_1$, the value of a is constantly less than a_0 but greater than a_1, the resultant rolling of the wheel must lie between R_1 and R_0; so, too, the rolling of the wheel due to rotation of the pointer between d_0 and d_2 lies between R_2 and R_0', where

$$R_2 = (k \cos a_2 - l)\frac{x'}{2}, \text{ and } R_0' = (k \cos a_0 - l)\frac{x'}{2}$$

In taking the value of R_0 for the true rolling due to the rotation of the pointer between d_0 and d_1, we commit an error; but, as the true rolling lies between R_1 and R_0, the error is less than $R_1 - R_0 = k x'(\cos a_1 - \cos a_0)$. By continued subdivisions of the angle x, the successive values of a may be made to approach each other more and more closely, and, as the angle x grows smaller and smaller, the error may be made as small as we please.

We conclude, then, that the total rolling of the wheel caused by the motion of the pointer along $d_0 d_0'$ is the limit of the sum of the rollings due to the motions of the pointer over the circular arcs $d_0 m_2$, $d_2 m_3$, etc., and the corresponding radial lines $m_2 d_2$, $m_3 d_1$, etc. The same, of course, applies to the motion of the pointer over $r_0 r_0'$. It may be well to repeat that all rollings of the wheel caused by radial motions of the pointer are finally balanced; that is, their sum is zero, after the pointer has been moved over the figure. Thus, the motion from m_1 to d_1 balances the motion from m_1' to m_0, and the motion from m_0 to r_0 balances the motion from n_0 to d_0; or, if we first move the pointer along $d_0 d_0'$, it will be remembered that the radial component of this motion is equivalent to the motion from m_0 to d_0', and will, therefore, be counteracted by the motion from d_0' to m_0, after the pointer has reached d_0' and is moved along $d_0' r_0$.

It is now easy to show that, when the pointer is actually moved over the straight lines $d_0 d_0'$, $d_0' r_0$, $r_0 r_0'$ and $r_0' d_0$, the total rolling of the wheel will measure the total area $d_0 d_0' r_0 r_0'$. For, let W_t be the rolling of the wheel corresponding to this motion, and S_t be the true area of the rectilinear figure $d_0 d_0'$, $r_0 r_0'$. The constant factor h is supposed to be included in the value of W_t. If possible, let W_t differ from S_t by any quantity u, however small, or let

$$S_t - W_t = u. \qquad (6)$$

Let S_a be one of the approximate values of the area found by the addition of several curved trapezoidal areas, and let W_a be the corresponding rolling of the wheel. It has been shown that $S_a = W_a$, and that, by increasing the number of central angles, both $S_t - S_a$ and $W_t - W_a$ may be made as small as we choose. Let S_a be an approximate area differing from the true area S_t by a quantity v less than $\frac{u}{2}$, and let W_a be the corresponding

rolling, differing from W_t by a quantity v', also less than $\frac{u}{2}$. Then we have,

$$S_t = S_a + v,$$
$$W_t = W_a + v'.$$

Subtracting, and bearing in mind that $S_a - W_a = 0$, there results,

$$S_t - W_t = v - v',$$

which contradicts equation (6); for v' and v being both less than $\frac{1}{2}u$, their difference cannot possibly be equal to u—not even if we give v and v' all possible signs and values between zero and $\pm\frac{u}{2}$. Therefore, the assumption that there may be a difference between S_t and W_t is incorrect, and we conclude that $S_t = W_t$; that is, that the area of the figure $d_0 r_0$ is exactly measured by the rolling of the wheel ($W_t = h\,W$), when the pointer is moved over the outline of the figure.

The same reasoning we have employed in treating of straight-lined figures applies to the case of curved-lined figures, and we shall, therefore, not consider the latter case separately.

In Fig. 5 is represented an area $A\,B$ to be measured by means of the planimeter. If we fix the anchor point at e and divide the

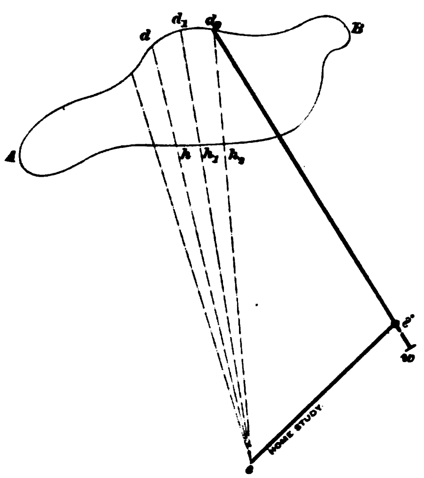


FIG. 5.

area into parts bounded by radial lines $e\,d$, $e\,d_1$, etc., we may move the pointer from d to d_1, from d_1 to h_1, from h_1 to h, and from h back to d; then raise the wheel while the pointer is moved to d_1, and then go over the outline $d_1\,d_2\,h_2\,h_1$, and so on. But here, as in the case of areas bounded by circular arcs, the rolling due to the intermediate radial motions, such as $d_1\,h_1$, is constantly counteracted, so that the effect will be the same if we simply move the pointer directly around the curved outline of the figure from d back to d.

Formula (5) is, therefore, perfectly general, whatever the form and extent of the area measured. There is, however, a fact that we have so far disregarded entirely. We have assumed the anchor point of the instrument to be outside of the area to be measured; but, when the area is very large, it is more convenient to place the anchor point inside, and in this case the formula just referred to has to be altered.

In Fig. 6, the anchor point is fixed at e, inside the area $A\,B\,C\,D$, whose contents are to be found. Describe a circle $Z\,Z$, with center at e and any radius r, so that its circumference will be inside $A\,B\,C\,D$. If the pointer is moved from A along a radial line to a point d on the circle $Z\,Z$, then to another point d_1, then along a radius to A_1, on the outline of the given figure, and then back to A, the resultant rolling of the wheel will measure the area $A\,d_1$, as we have seen. But the same is true, no matter how far d_1 is from d, or A_1 from A; thus, we may move the pointer from A to d, then to d_1', then to A_1', and then back to A; and, as before, the resultant rolling of the wheel will measure the area $A\,d_1'$. Or we may move the pointer from A to d, then around $d\,d_1'X$ to d_1'', then up to A_1'', then around $A_1''\,D\,C\,B\,A$ back to A; and the rolling of the wheel will measure the area $d_1''\,A_1''\,D\,C\,B\,A\,d\,d_1'\,Z\,X\,Z\,d_1''$. Therefore, if we move the pointer from A to d, then around the circle back to d, then up to A, then around $A\,D\,C\,B$ back to A, the resultant rolling will measure the area between the curved outline $A\,B\,C\,D$ and the circle $Z\,Z$. If we call this area U, and denote the total area $A\,B\,C\,D$ by S, the area of the circle by Z, and the rolling motions of the wheel, due to the motions of the pointer over $A\,B\,C\,D$ and $Z\,Z$, by W_u and W_z, respectively, we shall have (remembering that motion along $d\,A$ is counteracted by motion along $A\,d$)

$$S = U + Z = h\,W_u + h\,W_z + Z.$$

If we can find a circle for which $W_z = 0$, then we shall have

$$S = h\,W_u + Z. \qquad (7)$$

This is easily done; for, if we apply formula (4), noticing that here the value of x' is a whole circumference, or 2π, we get

$$W_z = 2\pi\,(k\cos a - l);$$

whence, by making $k\cos a - l = 0$, that is, $\cos a = \frac{l}{k}$, we get, $W_z = 0$, and $S = h\,W_u + Z$.

In this case, then, it is only necessary to move the pointer around the outline $ADCBA$, multiply the rolling of the wheel by h, and add the constant quantity Z. This constant is very easily determined; for we have (Fig. 6)

$$Z = \pi r^2,$$

and the triangle $e\,i\,d$ gives [see formula (1)]

$$\overline{ed}^2 = r^2 = h^2 + k^2 + 2\,k\,h \cos a\,;$$

or, because $\cos a = \frac{l}{k}$,

$$r^2 = h^2 + k^2 + 2\,h\,l,$$

and $$r = \sqrt{h^2 + k^2 + 2\,h\,l}. \qquad (8)$$

It is easy to see why the value of a, corresponding to $\cos a = \frac{l}{k}$, prevents all rolling of the wheel, so long as that angle is not changed. Referring again to Fig. 6, if we join $e\,w$ we shall have a triangle $e\,w\,i$ which is right-angled at w, since, by hypothesis, $\cos a = \frac{l}{k}$. Now, when the pointer revolves around ZZ, the wheel moves over the circle WW; and, as at every moment the direction of the motion of the wheel takes place in the direction of its axis, there can be no rotation of the wheel—all the motion will be slipping. Otherwise stated, the wheel is constantly pulled in the direction of the tangent $w\,d$, and this pull can produce no rolling of the wheel, for rolling is motion perpendicular to the axis, and no pull can produce motion in a direction perpendicular to its own direction.

The circle ZZ is variously known as the *corrective circle* and the *zero circle*.

After what has been said with respect to the direction of the rolling of the wheel, it is scarcely necessary to add that formula (7) is general, and applies in all cases in which the anchor point is fixed inside the area to be measured: whether W_u is positive or negative, it is to be added *algebraically* to area Z. Take, for instance, the area $ADGEFBA$, Fig. 6. If we move the pointer around $ADGXFBA$, the resultant rolling, as we have seen, added to Z, is equal to the area within $ADGXFBA$. If we move the pointer clockwise around $GXFE$, the resultant rolling, we have also seen, represents the area $GXFE$; but, since there is no rolling due to the motion of the pointer from G to F along the arc GXF, the area $GXFE$ is measured by the rolling of the wheel, due to the motion of the pointer over FEG. When the pointer is moved along GEF, the rolling is equal but opposite to the rolling due to the motion of the pointer over FEG; therefore, in moving the pointer over $ADGEFBA$, the rolling of the wheel, compared with the rolling due to the motion of the pointer over $ADGXFBA$, is diminished by the rolling due to the motion of the pointer over GEF; and, as this rolling represents the area $GXFE$, and the other rolling (going over GXF) includes the whole area $ADGXFBA$, it follows that the diminution in the rolling measures the diminution in the area, and the area $ADGEFBA$ is equal to Z plus the rolling of the wheel. If all or a great part of the outline of the area to be measured lies inside the zero circle, the resultant rolling, being negative, must be subtracted from (or added algebraically to) the area of the zero circle.

To sum up:

Let c = circumference of wheel;
n = number of revolutions of wheel;
A = area to be measured;
Z = area of zero circle.

Then,

First: anchor point outside of area,

$$A = h\,c\,n. \qquad (9)$$

Second: anchor point inside of area,

$$A = Z \pm h\,c\,n, \qquad (10)$$

the *plus* sign to be used when the reading of the wheel increases, and the *minus* sign when the reading of the wheel decreases. The pointer is supposed to move clockwise.

In some instruments, the length h of the circumscribing arm is made fixed, and the circumference c of the wheel is made equal to $\frac{10}{h}$, so that $h\,c = h \times \frac{10}{h} = 10$, and $A = 10\,n$, or $Z \pm 10\,n$. The value of Z, together with the other dimensions, is given by the maker, but may be found by circumscribing a known area (as a circle of known radius) with the anchor point inside the area, and observing the number of revolutions. Then, from formula (10), $Z = A \mp 10\,n$.

When this is done, several areas should be measured, and a mean taken for Z. Or, if the other dimensions are known, the radius of the zero circle may be found by formula (8).

In the best instruments, however, the circumscribing arm is graduated and adjustable, and it may be set so that each revolution will measure any required number of square inches.

Let it be required to set the arm so that one revolution will measure s square inches. Then we must have [formula (9)]

$$s = h\,c \times 1\,;$$

whence $$h = \frac{s}{c}.$$

As the vernier reads to thousandths of a

revolution, each unit of the vernier is .001 of a revolution; the instrument, therefore, will read to a fraction of a square inch equal to $\frac{s}{1,000}$. Thus, if $s = 1$ square inch, the instrument will read to thousandths of a square inch. In this case, $h = \frac{1}{c}$. If the vernier is to read .01 of a square inch, then $s = 1,000 \times .01 = 10$, and $h = \frac{10}{c}$. It is not, however, advisable to make the arm too short.

In measuring an area, it is not necessary to set the wheel at zero before beginning; it

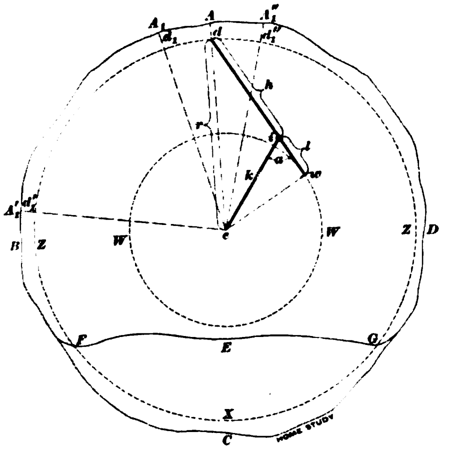


FIG. 6.

is enough to read the wheel before and after the outline of the figure has been gone over with the pointer, and then take the difference, due attention being paid, when the anchor point is inside the area, to the direction of the total rolling. When convenient, it is preferable to set the anchor point outside, as in this case any error in the area of the zero circle is eliminated. When the area is too large, it may be divided into parts by straight lines, each area determined separately, and the results added; but it is better, if practicable, to measure the whole area by one operation.

If a figure is drawn to scale, its area may be found in square inches, and then multiplied by the proper factor of reduction. Thus, suppose a figure is drawn to a scale of 100 feet to the inch, and that the area of the diagram is 50 square inches. Then, since the areas of similar figures are proportional to the squares of their lineal dimensions, we have, denoting by S the required area in feet,

$$S : 50 = 100^2 : 1;$$

whence, $S = 500 \times 100^2 = 5,000,000$ sq. ft.

$$= 113 \text{ acres, nearly.}$$

In general, if r is the scale of the drawing (as 100 in the preceding example), and A the area of the diagram in square inches, then

$$S = A\,r^2.$$

If the planimeter is used, $A = h\,c\,n$ (or $Z \pm h\,c\,n$), and

$$S = h\,c\,n\,r^2 \text{ (or } Z \pm h\,c\,n\,r^2\text{)}.$$

As we may change h at pleasure, we may fix it so that $h\,c\,r^2$ will be a convenient quantity to multiply by. In the example given above, assume $h\,c\,r^2 = 100,000$, or $h = \frac{100,000}{c\,r^2}$. Here $r = 100$; and, taking $c = 2.5$, we get

$$h = \frac{2.5 \times 100^2}{100,000} = \frac{10}{2.5} = 4 \text{ inches.}$$

If we set the arm so that $h = 4$ inches, the area of the figure, *already reduced to square feet*, will be found by multiplying the reading of the planimeter by 100,000. The value of c usually lies between 2 and 3, and the value of $h\,c\,r^2$ should be so assumed as to obtain a convenient value for h.

We might give examples illustrating some of the numerous and varied applications of the planimeter, but this would require too much space, and add little to the value of this article.

THE STUDY OF INSECT LIFE.

Adam Kaufman.

USEFULNESS OF THE STUDY—THE HARMLESS DRAGON FLY IN ITS FOUR STAGES—COLLECTOR'S EQUIPMENT—KILLING, MOUNTING, AND PRESERVING SPECIMENS.

THE chief objects of the study of *entomology*, as the science treating of insects is called, are the training of the powers of observation, and the careful ascertaining, in a scientific manner, of facts relating to the lives and habits of insects that are beneficial or injurious to vegetation.

It is estimated that there are in North America alone thirty thousand species of insects that have already been described; and that there are two million species of insects in the world.

Few words only are necessary to indicate the importance of entomology to mankind, and especially to the farming community. Farming must now be regarded as a science demanding research and investigation, and as a profession calling for the highest order of thought. Physical forces are no longer the dominant factors of success, the ability to work intelligently and to plan wisely being of equal or even greater importance. The farmer must understand the forces which are constantly at work in nature's great laboratory, and the ravages of insect pests and fungus growths are among the elements which he must understand.

FIG. 1.

While insects play a most important part in the economy of nature, and furnish some valuable products, and otherwise do us a great deal of indirect good, yet they are chiefly known by the annoyances they cause and the great injury they do to our crops and domestic animals. Every year, millions of dollars worth of food products are destroyed by these foes of vegetation, and one would suppose the entire community would act and try to prevent or lessen this destruction.

Locusts and caterpillars are among the most injurious insects. One of the most beneficial is the dragon-fly, or darning-needle, as it is more commonly called; and it is a pity that children should be taught to fear this beautiful, harmless creature by the silly legend that it will sew up their eyes and ears. The dragon-fly is the most harmless creature in existence, utterly incapable of injuring either man or beast, but on the contrary highly beneficial in all its stages, inasmuch as it is the natural enemy of mosquitoes, house-flies, moths, and other noxious insects, which would abound in far greater numbers and interfere much more seriously than they do with our comfort and nature's products, if it were not for the continuous and effective check of the dragon-fly.

The four different stages, the egg, larva, pupa, and imago of a dragon-fly, are shown in Fig. 1. The female lays her eggs by submerging her body under the surface of the water and gluing her eggs to reeds or sticks, as at *a*. After the eggs are hatched, the larva *b* feeds upon other aquatic forms of animal life—to a large extent upon the larvæ of the mosquito. It is provided with a mandible weapon, with which it catches its prey. The larva changes to the pupa state *c*, and when ready for transformation crawls out of the water up the stem or branch of a plant, secures a firm hold, and remains there until the skin is dried; the skin then splits on the back and the perfect insect *d*

emerges. A short time is required for the wings to expand and dry; it then flies away, leaving the pupa case clinging to the plant.

Insect life as a study is not only useful to those engaged in agricultural pursuits, but is also valuable to the artisan engaged in decorative art, the principles of design being largely derived from nature. The beautiful colors and graceful outlines belonging to many insects render them attractive subjects for study. Fig. 2 shows a design for wall paper and border, composed of different species of moths and butterflies. Any one can find out something new regarding insect life, and insect architecture, and the ways in which these creatures build nests for themselves or for their young. It is easy to observe remarkable feats of engineering, examples of foresight, wonderful industry, unremitting care of the young, tragedies, and even war and slavery.

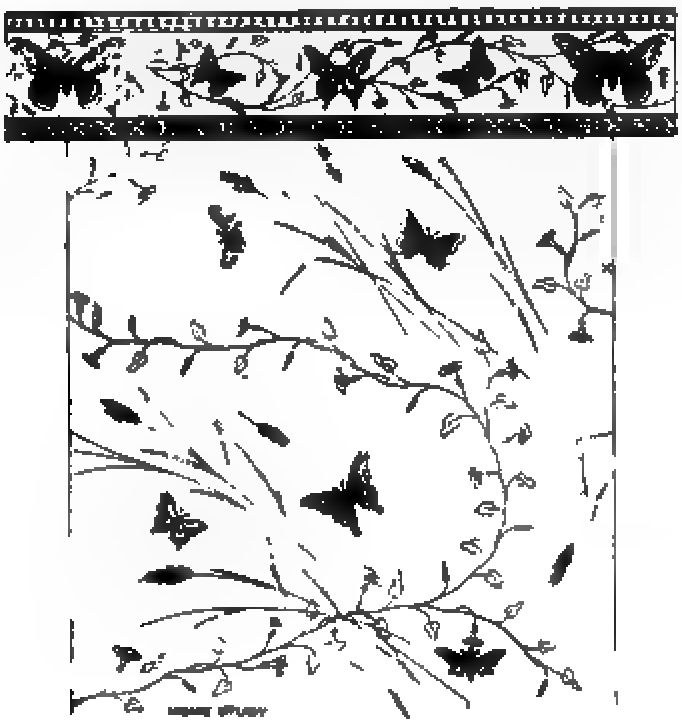


FIG. 2.

By watching the wonderful transformation of insects, the powers of observation will be trained and a love for nature developed. Fig. 3 shows the different stages of the transformation of a *telea polyphemus* moth; at *a* are the eggs, at *b* the larva (caterpillar) feeding on its food plant (leaves of plum and cherry tree); when full grown it weaves a silken cocoon *c* enclosed in a rolled leaf, in which it changes to the pupa state, and the following spring the imago *d* emerges with its body about twice its normal size, filled with a greenish oil, its wings being small, soft, rubber-like flaps hanging loosely at its sides. By compressing its body it forces the oil into its wings, which can be seen to grow to full size in about fifteen minutes; then the wings dry, and it is ready to fly away, or be killed for the cabinet, as the case may be. As a rule, perfect specimens can be obtained only by rearing them from the cocoon.

In collecting insects, a beginner need only equip himself with a few things, such as a butterfly net, an umbrella, a cyanide bottle,

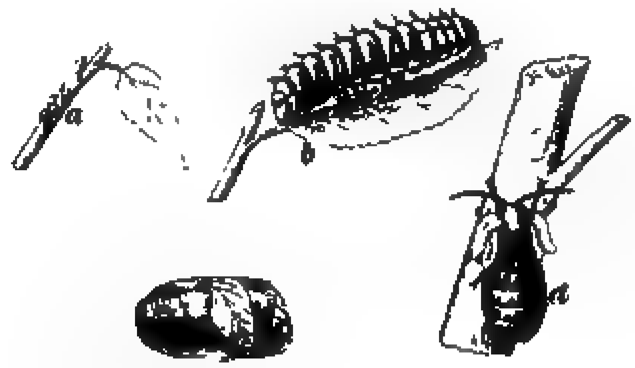


FIG. 3.

small bottle of gasoline, a cigar box, and an old chisel for digging into the ground or into decaying stumps and logs.

A hand net is one of the most important requisites. There are many kinds of nets, but one of the simplest is the one represented in Fig. 4. This any schoolboy can construct, very little mechanical ingenuity being necessary; or any tinsmith will make the frame for a few cents. It consists of a stout brass wire frame, ordinary telegraph wire will answer the purpose, bent in a circle of from 12 to 18 inches diameter with two free ends about 4 inches long, as at *a*, Fig. 4; these ends are soldered on to a tin ferule *b*, into which can be inserted a stick 4 or 5 feet long. The net *d*, is made of ordinary mosquito netting, and should taper to the bottom; its length should be about twice the diameter of the ring, so that when you give the net a

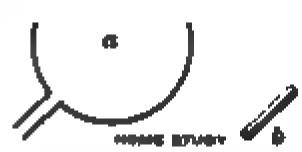


FIG. 4.

twist the mouth will be closed and the contents thus secured.

This net, when completed, can be used for various purposes, such as catching butterflies, moths, and beetles on the wing, or for sweeping grass, or beating bushes for caterpillars, beetles, and other insects.

Fig. 5.

Another article of good service is an ordinary umbrella, which when opened, and inverted is held with the left hand under the branch of a tree or shrub, while with the right hand the branch is beaten with a stout stick; in this way many rare specimens may be obtained.

(a) (b)

Fig 6.

Specimens not intended for rearing should be killed immediately after capture, otherwise, if put alive into a bottle or box, the larger ones will crush or injure the more delicate ones.

There are several methods of killing insects, each having its own peculiar advantages and drawbacks; butterflies and moths can be almost instantly killed by moistening the under side of the head and thorax with chloroform, ether, or gasoline; this can be done with a small brush. In Fig. 6, (a) shows a bottle containing gasoline, with a brush c securely fastened into the cork. The cyanide bottle (b) finds most favor with collectors, for the killing of large specimens.

Take a wide-mouthed bottle about 4 or 5 inches high, drop into it a few small lumps of cyanide of potassium; mix in a convenient vessel a quantity of plaster of Paris with just sufficient water to make a semifluid mixture and then pour it over the cyanide so as to cover it up by about a quarter of an inch. The bottle should be left open until thoroughly dry, when it is ready for use; insects dropped into it will die in a few moments from the poisonous fumes.

Upon the return from a collecting trip, the specimens should be prepared for the cabinet as soon as possible, or at least before they get dry and brittle. Pins especially adapted for mounting insects can be bought from any dealer in natural-history supplies; these pins are long, slender, and sharp; ordinary pins are too short and clumsy. Butterflies, moths, bees, and grasshoppers should be pinned through the middle of the thorax, which is that part of the body to which the legs and wings are attached. Beetles should be pinned through the right-wing cover, and

Fig. 7.

should all be at the same height on the pin. Fig. 7 shows a spreading board. The ends a should be ¾ inch high, about ½ inch thick, and as long as convenient; b, b, b are strips ¼ inch thick and ½ inch wide nailed on a lengthwise; over these is fastened a piece of thick, strong, wrapping paper d; c is a thin board nailed across the bottom of a a. The pins stuck through the paper d should all

touch *c*; in this way you will have all your insects mounted at the same height on the pins. The legs and wings can be spread to take their natural positions.

For butterflies and moths you should have a spreading board, as shown in Fig. 8. It may be made any length; the ends *a* are

FIG. 8.

FIG. 9.

¼ inch thick, to which is tacked a ⅛-inch bottom *c*; the top consists of two ½-inch boards *b* left wide enough apart to admit the body of the insect to be spread, and sloping towards the opening *f* to counteract a tendency the wings have, however well dried, to drop a little after the insect is placed in the cabinet. A piece of thick paper is fastened across the opening *f* on the lower side of *b b*; there should be a ¼-inch space between it and the bottom *c*. Place your insect in position, and, with a needle fastened into a wooden handle in the way shown in Fig. 9, spread the wings so that the inner margins of the front wings are as nearly as possible in a straight line *x y*. The wings are held in position by means of strips of paper *d d*, or by a piece of glass *e*.

In making spreading boards, the lids and sides of cigar boxes can be used; several spreading boards of different sizes should be kept, each large enough to hold a number of specimens. After an insect has been spread a few days, and is thoroughly dry and stiff, it may be taken from the board and placed in your cabinet or insect case.

The cabinets used by some entomologists are very elaborate, but ordinary glass-covered boxes will do, for temporary purposes, cigar boxes are convenient and economical. Strips of cork should be glued in the bottom of the boxes, as the insect pins will bend if stuck in wood.

A section of an insect case for permanent use is shown in Fig. 10. It may be made of any dimensions to suit the fancy; 12 by 16, 14 by 18, 16 by 20 inches are convenient sizes. They must be perfectly tight, so that your insects will not be ruined by little red ants, which are fond of dead and dry insects. Well seasoned pine or whitewood ⅜ inch thick, may be used for the sides and bottom; the case should not be more than 2½ inches deep inside. The top of the case should be rabbeted to receive the glass *a*, and a ⅜-inch half-round molding should be tacked over it to keep it in place. The bottom of the case should also be rabbeted to receive the bottom, the corners and joints being made tight by painting them with white lead; the outside of the case may then be shellaced and varnished. When this is done, line the bottom of your case with 1/16- or ⅛-inch sheet cork, which costs about fifteen cents a square foot; then line the inside of the case with clean white paper. In one corner of your case place a lump of moth camphor; this will keep away "museum pests," which are various kinds of small insects, that attack and destroy dry insects.

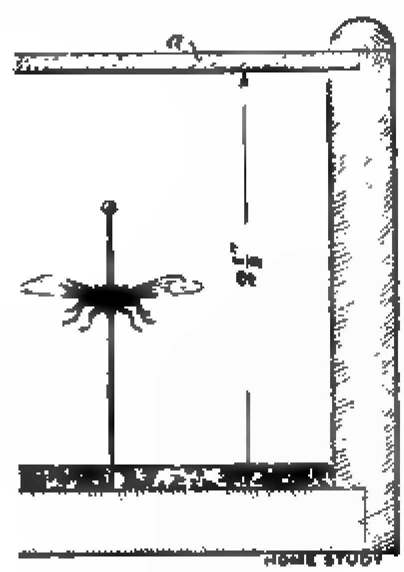


FIG. 10.

If you intend to display your collection on the wall, you must keep the cases covered with a dark curtain, as most insects, when exposed for any length of time to a strong light, fade, or lose color.

A pocket notebook should be kept, in which to write all facts worthy of notice, such as the date, time, and place of the capture of an insect, its food plant, and its habits.

All specimens should be properly classified and arranged, and labeled with technical name and date.

(To be Concluded.)

SALT AND SODA.

G. H. Dimpfel, Ph. D

SOURCES OF SALT SUPPLY—VARIOUS METHODS OF EXTRACTION—AN IDEAL PROCESS FOR MANUFACTURING SODA, INDIRECTLY ORIGINATED BY NAPOLEON I, IN WHICH NOTHING IS WASTED.

EVERY one uses salt, every one knows what salt is, and every one is aware that salt is as essential to human life as the daily bread for which we are praying and working. But very few of us know that in the history of the useful applications of salt is to be found one of the best illustrations of the influence of chemical research upon the development of the resources of a country, and, too, a wonderful example of a manufacturing process, not based, as such processes usually are, upon mere experience, independent of any knowledge of chemical principles, but upon a direct and intentional application of these principles to the achievement of a particular object.

Nature has supplied us most lavishly with salt; we find it widely distributed in the solid state as rock salt, and dissolved in sea-water and in mineral springs.

Rock salt forms vast deposits in nearly all parts of the globe; Wielitzka, in far away Poland, is celebrated for one of the most extensive salt mines, in which there is a church and a dwelling, which, together with the furniture, are made of this rock. Extensive beds of rock salt occur also in France, Germany, Hungary, etc. In some places, the extraction of salt is carried on upon scientific mining principles, while in other parts the methods of extraction are still rather primitive. In some countries, salt is extracted by simply boring holes in the rock, filling these holes with water, and, after the water has become saturated with salt, pumping it up again and evaporating it in boilers, removing the minute crystals of salt as they are formed. In other places, as for instance in Worcestershire, England, salt is obtained by evaporation from the water of certain mineral springs. In some parts of Germany, the waters of many mineral springs contain so little salt that it would hardly pay for the fuel necessary to evaporate the water, and a very ingenious plan has been adopted by which the proportion of water is greatly reduced without the application of artificial heat.

FIG. 1

For this purpose, lofty scaffoldings have been erected, which are filled up with bundles of brushwood and twigs through which the saline water is allowed to trickle,

having been raised by pumps to the top of the scaffolding and distributed there in a net of perforated pipes. In trickling down over the brushwood, this water exposes such a large surface to the action of the sun and wind that a considerable spontaneous evaporation takes place and much stronger brine is collected in the reservoir beneath the scaffolding. Fig. 1 shows one of these scaffoldings as used in Wittenberg, Prussia, and Sulza, Thuringia. By repeating this evaporating process several times, the water is so far diminished that the remainder can be economically and profitably evaporated by artificial heat.

The process adopted for extracting the salt from sea-water depends largely upon the climate of the different countries. In Russia, the sea-water is simply collected in pits dug out upon the shore, and the water allowed to freeze, when part of it separates as pure ice, leaving a solution of salt which is strong enough to pay for evaporation. Where, as in the United States, the temperature is sufficiently warm, the sea-water is allowed to run very slowly through a series of shallow pits upon the shore; thus being exposed to the breeze and sun, the water becomes concentrated by spontaneous evaporation and is afterwards allowed to remain in reservoirs, in which the salt is deposited. The mother liquor, or bittern, which remains after the salt has been extracted, is acted upon to extract from it the magnesia, bromine, and iodine which it contains.

The uses of common salt were for a long time limited to culinary purposes and to the glazing of some common kinds of pottery, and its usefulness as a raw material in the chemical arts was unknown.

Carbonate of soda, recognized already in the last quarter of the eighteenth century as a very important substance in the arts, was then chiefly imported from Spain under the name of *barilla*. Barilla is the ash obtained by burning a marine plant known as *salsola soda*, but as this ash contains only about 25 per cent. of carbonate of soda, and the transportation then was costly, the price of barilla was proportionately high, and the manufacturers of soap and glass, to whom it was indispensible, were considerably fettered.

During the wars of the French Revolution, the price of barilla had risen to such an extent that Napoleon Bonaparte, in order to help the manufacturers, and, if possible, create a new industry, deemed it advisable to offer a prize for the discovery of a process by which carbonate of soda could be produced at home.

To this circumstance we are indebted for the discovery, by Leblanc, of a process for the manufacture of soda carbonate from common salt, a discovery which placed salt at once among the most important and indispensable raw materials which a country can produce.

The process consists in heating salt and sulphuric acid, whereby sodium sulphate and hydrochloric acid are produced, according to the equation

$$\underset{\text{salt}}{2\,NaCl} + \underset{\text{sulphuric acid}}{H_2SO_4} = \underset{\text{sodium sulphate}}{Na_2SO_4} + \underset{\text{hydrochloric acid}}{2\,HCl}$$

The sodium sulphate, thus obtained and technically known as *salt cake*, is mixed with coal and limestone and again heated to convert it into sodium carbonate, a process which may be represented by the two equations:

$$(1)\ \underset{\text{sodium sulphate}}{Na_2SO_4} + \underset{\text{carbon}}{C_2} = \underset{\text{sodium sulphide}}{Na_2S} + \underset{\text{carbon dioxide}}{2\,CO_2}$$

$$(2)\ \underset{\text{sodium sulphide}}{Na_2S} + \underset{\text{calcium carbonate}}{CaCl_3} = \underset{\text{sodium carbonate}}{Na_2CO_3} + \underset{\text{calcium sulphide}}{CaS}$$

The resulting mixture of sodium carbonate and calcium sulphide, termed *black ash*—being black from the presence of coal—is mixed with water, which readily dissolves the sodium carbonate, leaving the calcium

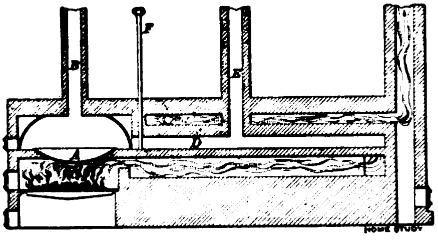


FIG. 2.

sulphide undissolved as so-called tank-waste. The water is evaporated and the sodium carbonate obtained as crystals.

From these outlines, the process employed in the manufacture of sodium will now be readily understood.

In the first part of the process, which is known as the "salt-cake process," equal parts of common salt and sulphuric acid are mixed and heated in an iron pan A of a furnace (Fig. 2) by a fire in the grate C. The hydrochloric acid gas evolved rises and escapes through flue B, whence it passes to a brick tower filled with coke, down which a fine shower of water trickles. The

entering hydrochloric acid gas is readily absorbed by the water, forming with it the muriatic acid of commerce. From pan *A* the partly decomposed salt is transferred through the raised door *F* into a brick roaster *D*, which is virtually a muffle heated by the flames from the furnace, which circulate in the flues surrounding it. The conversion of the salt into sodium sulphate is here completed, the still evolving hydrochloric acid gas being allowed to escape through flue *E* to condensing-towers constructed similarly to the one described.

The second part of the process takes place in a reverberatory furnace, known as the black-ash furnace. In this furnace, a mixture of 10 parts of ground salt cake, 10 parts of limestone, and 4 to 6 parts of small coal are heated. To the black ash obtained, water is added to dissolve the sodium carbonate; the solution is then drawn off, and through evaporation and calcining the residue, ordinary crude soda, is obtained. This soda is, of course, far from being pure, as it contains, in addition to a considerable amount of salt and sodium sulphate, a certain amount of caustic soda, formed by the action of lime upon the carbonate.

The crude soda ash is purified by mixing it with sawdust and heating the mixture. The carbonic acid gas formed by the heated sawdust converts the caustic soda into carbonate, and by dissolving the mass in water and evaporating the solution, crystals of common washing soda, having the composition $Na_2CO_3 + 10\ H_2O$, are obtained.

As it is one of the first principles of chemical manufacture to utilize the raw materials in such a way that all elements in them, at the end, appear in some marketable form, the calcium sulphate which was left behind as tank-waste is not forgotten. It undergoes a process, discovered by chance, and is converted into marketable sulphur.

A little reflection will show the influence which the discovery of this process has exerted upon the arts. The three raw materials, salt, limestone, and coal, are abundant in this country. The sulphuric acid was expensive when the Leblanc process was first introduced, but the resulting demand for it gave rise to so many improvements in its manufacture that in a comparatively short time the price greatly diminished, a circumstance which, of course, produced a most beneficial effect upon the multitude of branches of manufacture in which sulphuric acid is employed. The large quantities of muriatic acid, obtained as a secondary product, are employed in the preparation of bleaching powder, and the important arts of bleaching and calico-printing have received a considerable impetus. These arts have also derived a more direct benefit from the increased supply of soda, which is largely used for cleaning all kinds of textile fabrics. The manufacture of soap and glass, which probably creates the greatest demand for it, has been increased and improved beyond precedent by the production of soda from native sources.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Nicaragua Canal.

Geology teaches us that in far distant prehistoric time North and South America were linked together by a chain of islands, and that through the straits between those islands the waters of the Atlantic and Pacific Oceans flowed freely. Great convulsions of nature took place in that dim past—which are recorded on the face of the earth itself, in handwriting comprehensible only to the trained scientific eye. Hill and valley, lake and river, volcanoes—both active and extinct, with their deposits of lava and ashes—tell of the seismic action which has frequently been felt even in the present century, and which by slow degrees has changed the island chain into a solid isthmus, and raised a barrier between the two oceans.

When Europeans first discovered this isthmus, they found, existing amongst the Indians, a tradition of a waterway across the rocky neck of land; and the early explorers spent many years in endeavoring to find this passage. When careful search proved to them that nature had closed the door, man boldly resolved to open it. "Mountains there are, but there are also hands;" said one enthusiast, filled with the spirit of that

wonderful age of adventure and achievement. The spirit has slumbered, but it never died. For nearly four hundred years men have dreamed, and thought, and planned, and labored; we have the record of more than thirty schemes for opening a way across these few miles of land; but all have proved abortive, and still the barrier confronts us.

The width of the isthmus at the narrowest part is only twenty-nine miles, but here the elevation of the intersecting mountain range is too great to admit of a cutting, and a tunnel, if practicable, would have to be seven miles in length. From Aspinwall to Panama the distance is forty-six miles, and here an unsuccessful attempt to construct a canal was made by the eminent French engineer, M. Lesseps, in 1881-1887. The work has never been entirely abandoned, but it is generally regarded as a chimerical scheme.

The route now most favorably considered passes through Nicaragua. It is by no means the shortest intersection of the isthmus, but at this point nature offers much friendly aid, and if man can use this help skilfully it may be that our ships will soon pass by a new short route from ocean to ocean.

The state of Nicaragua, lying midway in the great isthmus of Central America, is traversed by two mountain ranges, trending from northwest to the southeast. Between these two ranges, and within twenty miles of the Pacific lies a large lake, which is of such supreme importance in the plans for the Nicaragua Canal, that it may be called the key to the present scheme. By its height above the sea level, its size, and its general position, it helps to solve the problem of a constant, sufficient, and controllable water supply for the proposed artificial river. In most parts it is deep, and by dredging a channel for a few miles on the shallow eastern side it can be made navigable for large ships. The rivers of the surrounding country drain into this great natural reservoir, which has an area of 2,700 square miles, and the waters being thus diffused, there is no great and dangerous change of level in the rainy season. Flowing eastward from this lake towards the Caribbean Sea is the river San Juan which forms its only outlet, and constitutes part of the proposed canal For sixty-six miles the San Juan is a wide river, and already navigable for vessels of shallow draught, but midway in its course it becomes unsuitable for canal purposes. At Ochoa, near this point, it is planned that a huge dam, a solid structure 1,900 feet in length, shall be built from hill to hill diverting a large portion of the river water into an artificial channel which shall be constructed. The remainder of the water will flow through sluices and waste-weirs into the natural channel below the dam, and thus reach the Atlantic Ocean. It is believed that this dam will so regulate the flow of the water that a level—or almost a level—may be maintained from the lake eastward to a point eighty-six miles below it. In the bed of the San Juan river, midway between the lake and Ochoa dam, are three reefs of rock, and the rapids which they cause are dangerous, and would be impassable to large ships. Restrained by the Ochoa dam the waters will be held back, and the depth of the river will be greatly increased, so that the rapids will be submerged, and with some blasting in the bed of the stream will easily be passed over.

Other waters besides those of the lake will be used in the construction of the canal. Its course intersects several valleys, through which flow streams of considerable size. These valleys will be inclosed by dams and barriers from hill to hill, forming lakes, in which, to make a channel of the required depth, little excavation will be required. Between two of these basins, or artificial lakes, named from the streams which flow through them, the Deseado and the San Francisco basins, is the spot which, next to the Ochoa dam, offers the most serious obstacles to the success of the work. This is a rocky ridge, known as the Eastern Divide, and through it a channel must be opened which will be about three miles in length, and will average one hundred and forty feet in depth. Twelve million cubic yards of rock and clay must be excavated in order to form a passage of the required dimensions. The material obtained from these excavations will be used for building the necessary dams and embankments. A few miles further to the east, separated by short intervals, will be three locks, by means of which the level of the water of the canal will be changed from that of the lake to that of the sea. Each lock must be large enough to hold a great ocean steamer, and the proposed dimensions are 650 feet in length by 80 feet in width. The combined lift of the three locks will be 106 feet, and beyond them the canal will flow entirely through an artificial channel for nearly ten miles to Greytown, its eastern terminus. Within this century a good harbor existed at Greytown; but the shifting of the sands, under the influence of the wind and waves, has closed its entrance, and in order to restore it breakwaters and jetties must be constructed, and much dredging will be necessary.

If the time ever comes when a vessel can cross the isthmus by this proposed route it will enter the harbor of Greytown, pass westward, through a cut of nine or ten miles, to the three locks, which will raise it to the level of the distant lake; thence through the Deseado basin—the great three-mile cutting through the Eastern Divide—the San Francisco and Machado basins—past the colossal Ochoa dam—into the San Juan river, and onwards into the lake itself, the main source of supply of the water on which ships will float from ocean to ocean. After passing through the lake the vessel will enter the western division of the canal. which extends from the lake to the Pacific, and is only seventeen miles in length. An elevation known as the Western Divide lies between the lake and the ocean. It is lower than the ridge on the eastern coast, and the maximum depth of the channel which must be excavated through it is less than half that of the other. The cut will, however, be five miles in length. About four miles from the sea it is proposed that another great dam shall be erected, converting the Tola valley into a basin or lake, and that three locks of the size of those at the eastern end shall lower vessels again to the level of the ocean. At Brito, the Pacific terminus of the proposed canal, an artificial harbor must be constructed by means of dredging, and by the building of breakwaters and piers. The time required for the passage of a vessel from one ocean to the other will be about twenty-eight hours.

It is impossible, in this slight sketch to do more than indicate the colossal character of the work to be done if the Nicaragua Canal is to become an established fact. The whole waterway will be 170 miles in length, with a depth of 30 feet, and a minimum width at the bottom of 100 feet, widening towards the top. For twenty-seven miles the channel must be entirely artificial, and in the parts in which there is said to be "free navigation" through lake and river and basins, there is much to be done in the way of excavating, dredging, and embanking. At the eastern end a harbor must be restored; at the western end, one must be created; to say nothing of two other harbors on the shores of the lake itself, neither of which yet exists; two great dams must be built; embankments of varying height, aggregating several miles in length, must be constructed to retain the waters within the valleys or basins which form part of the waterway; and no less (perhaps more) than $100,000,000 will be spent during the six years which, at the lowest computation, will be required for the completion of the work.

But the advantages to be gained by the construction of the canal are at least commensurate with this vast expenditure of time and money. From a commercial point of view they can hardly be overestimated. The Atlantic and Pacific shores of our country would be practically united, promoting and increasing the coasting trade on either side. The voyage from our eastern ports to San Francisco would be shortened by 10,000 miles; China and Japan would become accessible to all our eastern centers of production; the impetus to trade would be felt throughout the whole country, for it is an axiom that

facilities for the transaction of commerce always induce its development and growth.

All indications point to a convergence of European interests in the China Sea, and now Admiral Dewey has won for the United States a seat in the council which must control the destinies of this region. To each and all, the Nicaragua canal will be of great importance, but to the United States such a link between the two oceans will be invaluable. Recently the battleship Oregon spent eight weeks steaming from San Francisco to Florida. Had the canal existed, 10,000 of these 14,000 miles would have been saved.

The value of such a work is demonstrated by the results of the practical operation of the Suez Canal, which has been in use for nearly thirty years. About 8,000,000 tons of shipping now pass through it annually, and more than four-fifths of this belongs to European ports to which the saving in distance is only from one to four thousand miles. If, with this comparatively small saving, it is worth while to pay canal dues, it is easy to see how great would be the advantage when the economy in mileage is two or three times as large.

Americans are not accustomed to regard any difficulties as insuperable. "Mountains there are, but there are also hands"; and the hands are those of a persistent and ingenious people, who, many times in the course of their history, have made Nature their friend, and triumphantly converted her forces into their tools.

THE SPANISH-AMERICAN WAR.

May 22d, 1898. Cruiser Charleston sailed from San Francisco for Manila with supplies and ammunition.

May 25th. Transports Pekin, Sydney, and Australia sailed from San Francisco for Manila with 2,500 troops. Battleship Oregon arrived off Florida, after a voyage of 13,600 miles from Puget Sound. President McKinley issued a call for 75,000 additional volunteers.

May 29th. American vessels Texas and Brooklyn repelled attacks of torpedo-boat destroyers.

May 31st. Commodore Schley, with vessels Massachusetts, Iowa, and New Orleans made reconnoissance and bombarded the harbor defences at Santiago de Cuba, where a Spanish squadron was found to be lying, under command of Admiral Cervera.

June 1st. North Atlantic squadrons under Sampson and Schley unite. First detachment of American troops bound to Manila touch at Honolulu.

June 3d. American fleet opened fire on the fortifications at Santiago. The collier Merrimac, loaded with 2,300 tons of coal, was taken with great gallantry by Lieut. Hobson and a volunteer crew of seven, into Santiago harbor, and sunk by prepared torpedoes across the entrance channel. Admiral Cervera courteously promised good treatment of the brave volunteer officer and crew, who were picked up by the Spanish after escaping from the sunken vessel on a raft. Admiral Dewey reported victories of the Philippine insurgents over the Spaniards.

June 6th. Forts at Santiago bombarded by the American fleet, and two batteries wrecked. These fortifications were under fire at intervals until June 18th. Battleship Massachusetts injured. Spanish cruiser Reina Mercedes was reported seriously injured.

June 8th. Battle of Caimanera, and bombardment of forts at Guantanamo; continued at intervals until the 11th, and from the 14th to the 19th. American vessels took possession of the outer bay of Guantanamo.

June 10th. 850 marines landed at Guantanamo.

June 11th to 14th. Continuous fighting between marines and Spanish troops in the neighborhood of Guantanamo. American loss, 4 killed, 2 wounded.

June 13th. The war loan of $200,000,000 approved by Congress.

June 14th. Gen. Shafter sailed from Tampa with 15,000 troops for Cuba. Four transports sailed from San Francisco for the Philippines with 3,500 troops.

June 19th. Manila was reported to be surrounded by insurgents, who had taken 3,000 Spanish prisoners.

June 20th. American troop ships, with convoy, arrived off Santiago. Admiral Sampson and Gen. Shafter met Gen. Garcia at his camp at Acerraderos for consultation on the plan of campaign.

Spanish vessels captured: May 31st. Bark Maria Dolores; and on June 10th, collier Twickenham, with 3,200 tons of coal for the Spanish fleet; by auxiliary cruiser St. Louis.

Our record closes on June 20th.

FRUIT PRESERVING.

Mrs. Henry Esmond.

Strawberry, Raspberry, Blackberry, and Gooseberry Jams and Preserves—Choice and Preparation of the Fruit.

THIS is the time of the year when the good housewife is busy making preserves and jams. Of course, good preserves, etc. can be bought, but a great saving is effected by making them yourself, and you also have the satisfaction of knowing what is in them. Preserves, pickles, sauces, etc. are not, of course, necessary articles of diet, that is, we could live without them and enjoy good health too; but they are decidedly palatable, and by adding a "smack," as it were, make a good meal better; they also improve the appearance of a table.

Strawberry Jam.—Strawberries and all other berries should not be overripe nor gathered immediately after a fall of rain, as they are then apt to be watery; they should be ripe, perfectly fresh, and sound. Hull the strawberries and, if they are sandy, wash them in cold water; then put them in a cullender and let them drain. The strawberries may be left whole or mashed, though it is better to mash them, as they break during the cooking, anyhow.

Always use a granite or porcelain kettle in preference to tin or brass, as the acid in the fruit acts upon the metal and forms a poisonous compound. Measure the strawberries and allow equal parts of fruit and sugar. Do not use cheap sugar, but good, fine, granulated. Put the strawberries and half the sugar into the kettle, and boil for 5 minutes; then add the remainder of the sugar and boil 30 minutes. Skim often and be very careful that it does not burn. Asbestos mats are very useful in all preserving and pickling; for, when fruit and pickles have to cook any length of time, it is almost impossible to keep them from sticking to the bottom of the kettle. When the jam is done, pour it into large-mouthed bottles or glasses which are standing in a shallow pan of hot water. This prevents the jars from breaking. A silver fork or spoon placed in the jar is also a help, as the silver quickly carries off some of the heat. Let the jam cool; then pour 1 tablespoonful of brandy over the top, or cut out some round pieces of white paper to fit over the top of the jam, and dip these in brandy; this is more economical, as 1 tablespoonful of brandy for each jar soon uses up a pint. Cut out some round pieces of paper large enough to entirely cover the top of the jar and come down for an inch or so on the sides; paste these on with flour paste. Keep all preserves, jams, etc. in a dark, warm, dry place; if they are kept in the basement they are apt to mold. With canned fruit and pickles it does not matter if they are kept in a cold, damp place.

Raspberry, blackberry, and gooseberry jams are made in the same way. When making red-raspberry jam add ¼ pound of red currants to every pound of raspberries; they improve the flavor.

Preserved Strawberries, Raspberries, and Blackberries.—The berries should be ripe, fresh, and sound. If they are sandy, wash them in cold water. Measure them and allow ¾ pound of granulated sugar to every pound of fruit. Into a preserving kettle put first a layer of fruit, then a layer of sugar, and let it stand over night. In the morning cook slowly until the fruit is soft; 20 minutes will be about the time required. This is one very good way. Another is: Put the sugar and fruit into the kettle in the morning, and let them cook slowly without stirring until the sugar is melted and begins to boil. Then boil briskly for 25 minutes. Skim frequently. Have the jars standing in a shallow pan of hot water to prevent their breaking. Fill them to the brim and screw the tops on immediately. As the contents cool, you will find that the tops can be screwed still tighter. Turn the jars upside down, and leave them this way overnight. If any of the jars are found to have leaked during the night, screw the tops tighter still, and when the jars are put away leave them turned upside down. There is then no danger of the air getting in.

When making red-raspberry preserve, use 1 bowl of red currants to every 4 bowls of raspberries; the currants brighten the flavor.

The following communication received from "Double-Header" may be of interest to some of our readers "In HOME STUDY MAGAZINE, May, 1898, Answers to Inquiries, No. 182, I notice that one reason given for placing a pilot or helping engine ahead, no matter of what class, is 'so that the regular engineer should have command of the train—in the matter of breaking, etc.' While this is in the main correct, yet it is not quite up to date, for the modern practice, on at least one large railroad is to give this command to the front engineman of 'double-headers,' or trains having two engines. This is accomplished by equipping locomotives with cut-out cocks, conveniently placed, so that when two engines are coupled to a train the engineer's valve on the engine next to the train is cut out and is inoperative except for emergency applications of the brakes. The factor of increased safety is the reason for this arrangement, as undoubtedly the front man has a better chance to see signals and danger ahead, and is therefore in a position to act with greater promptitude than the man next to the train, and we all know how very important it is, in these days of heavy, fast trains and interlocking switches, that every second be taken advantage of, especially when the weather is foggy, or rails bad, owing to grease, light rain, etc. The only exception made to the arrangement stated is in the case where helping engines are attached for only a short distance and when they have to cut off on 'the fly,' thereby avoiding detention to the train by stopping to cut off."

⁂

(305) (*a*) Can two Heisler series alternating-current dynamos be coupled together? If not, please explain why (*b*) How is the frequency of a Heisler series alternating-current dynamo calculated?

S. W., Northville, Mich.

ANS.—(*a*) It is not practicable to connect two alternating-current dynamos in series unless the armatures are on the same shaft, as they will not work in synchronism. Direct-current machines may be connected in series when it is desired to obtain a very high potential. (*b*) The frequency of any alternating current is equal to the number of revolutions per minute of the armature multiplied by one-half the number of poles.

⁂

(306) I have a problem which has been causing a good deal of discussion. Some say it cannot be worked, others that it can. Kindly settle the question, and, if it cannot be solved, give reasons. The problem is as follows: A hires B and C to dig a drain 100 rods long, C is to get 87½ cents, B $1.12½ per rod. They are to get $50 each for their work. How many rods has each to dig.

J. E., Windsor, Ont., Can.

ANS.—The problem, as stated, is impossible, because the given conditions are inconsistent with each other. This may be shown as follows: Suppose B digs x rods, then C must dig $(100 - x)$ rods. From the given conditions, we have

B's wages $= \$1.12\frac{1}{2} \times x = \$50$, therefore, $x = 44\frac{4}{9}$.

C's wages $= \$.87\frac{1}{2} \times (100 - x) = \$50$; therefore, $x = 42\frac{6}{7}$.

Since these two values of x are different, the problem is impossible. In the statement we are given more conditions than are necessary to determine the unknown quantities, and the additional conditions are inconsistent. If, instead of saying that B and C are to receive $50 each, we say that they are to receive $100 between them, we reduce the number of conditions by one, and we then have a possible problem, the answer to which is that B and C each dig 50 rods.

⁂

(307) Can you give me a rule by which I can calculate the horsepower of any dam?

J. M. R., Housatonic, Mass.

ANS.—The theoretical horsepower of a dam depends on the quantity of water flowing over it and the fall. The actual power that can be obtained from the water depends on the type of waterwheel used, and the correctness with which it is designed, built, and set, so as to use the water in an economical and efficient manner. These conditions may be expressed by the following rules. To find the theoretical power in the water flowing over a dam or fall, *multiply the quantity of water in cubic feet per second by the height of the fall in feet and this product by 1136.* To find the available horsepower, *multiply the theoretical horsepower by the decimal representing the efficiency of the waterwheel.* The efficiency of a good overshot wheel or of a turbine will vary from .50 to .85, according to the condition under which it works.

⁂

(308) (*a*) Is it a fact that the gases contained in the crevices of a coal seam have a pressure as great as that produced by a head of water equal to the depth of the seam from the surface? (*b*) On an endless-rope haulage system what is the proper proportion of tension on the tension carriage to load hauled? (*c*) Will a siphon discharge as much water as a standpipe—fall, size and length of pipe being identical? (*d*) How much water will be delivered under the following conditions: head, 100 feet; pipe line composed of 1,000 feet of 4-inch, 1,000 feet of 3-inch, and 1,000 feet of 2-inch pipe? Please give rule for solving this problem.

P. W., Weir City, Kansas.

ANS.—(*a*) No. The pressure of gases is, to a certain extent, dependent on the depth, but varies greatly, according to the character and condition of the enclosing strata. Earth movements may change the pressure. Bodies of gas comparatively near the surface, in impervious strata, are sometimes under a tremendous pressure, while the pressure of gases at considerable depths may be comparatively light. (*b*) The tension on the tension carriage depends upon the length and weight of the rope and is independent of the load hauled. (*c*) If the siphon is kept filled with water throughout its length, the discharge through it will be the same as through the pipe; there is a tendency, however, for air to collect in the highest point of the siphon, and, if this air is not removed, it will reduce the discharge. (*d*) The solution of this problem is a little difficult, and cannot be worked by a simple rule, as will be seen by the following: The velocity of flow through a pipe whose length is more than 1,000 times its diameter

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see contents page.

may be expressed in terms of the diameter of the pipe, its length, the head, and a coefficient that depends on the diameter of the pipe, the condition of its inner surface, and the velocity of flow. The equation that expresses this relation is

$$v = 2.315\sqrt{\frac{hd}{fl}},$$

in which v = velocity of flow in feet per second;
h = head in feet;
d = diameter of pipe in inches;
f = coefficient;
l = length of pipe in feet.

We know the total head, and it is first necessary to find the proportion of the head required to force the water through each length of the pipe. Referring to the figure, we will suppose a tube to be inserted at each of the joints a and b. If the lower end of the pipe is closed, the water will rise in each of these tubes until it reaches the level of the water in the reservoir; when, however, the lower end of the pipe is open, so as to allow the water to flow freely from it, the water in each of these tubes falls a certain amount, depending on the part of the head required to force the water through the part of the pipe between it and the reservoir. We will designate by x the distance that the water in the tube at a stands above the lower end of the pipe while the water is running; and the corresponding distance for the tube at b we will call y. Then, the part of the total head absorbed in forcing the water through the 4-inch pipe is $100 - x$; the part absorbed in forcing it through the 3-inch pipe is $x - y$; and the part absorbed in forcing it through the 2-inch pipe is y. We will assume the pipes to be smooth and free from rust, under which conditions the value of the coefficient f may be taken as .025 for each pipe. Calling the velocities in the successive pipes v_1, v_2, and v_3, and substituting in the formula for the velocity of flow, we have the following relations:

$$v_1^2 = \frac{2.315^2 \times (100 - x) \times 4}{.025 \times 1{,}000}; \qquad (a)$$

$$v_2^2 = \frac{2.315^2 \times (x - y) \times 3}{.025 \times 1{,}000}; \qquad (b)$$

$$v_3^2 = \frac{2.315^2 \times y \times 2}{.025 \times 1{,}000}. \qquad (c)$$

The quantity of water that flows through each pipe in a given period is the same, and is equal to the area of the pipe multiplied by the velocity of flow. Letting Q be the quantity in cubic feet per second, and a_1, a_2, and a_3 the areas of the successive pipes in square feet, we have the relations $Q = a_1 v_1$, $Q = a_2 v_2$, and $Q = a_3 v_3$. The area of a 4-inch pipe is .08724 square foot; of a 3-inch pipe, .04908 square foot; and of a 2-inch pipe, .02182 square foot; consequently, we have

$$v_1^2 = \frac{Q^2}{.08724^2}, \quad v_2^2 = \frac{Q^2}{.04908^2}, \text{ and } v_3^2 = \frac{Q^2}{.02182^2}.$$

Substituting these values in (a), (b), and (c), we have

$$Q^2 = \frac{5.36 \times (100 - x) \times 4 \times .007616}{25}, \qquad (d)$$

$$Q^2 = \frac{5.36 \times (x - y) \times 3 \times .002409}{25}, \qquad (e)$$

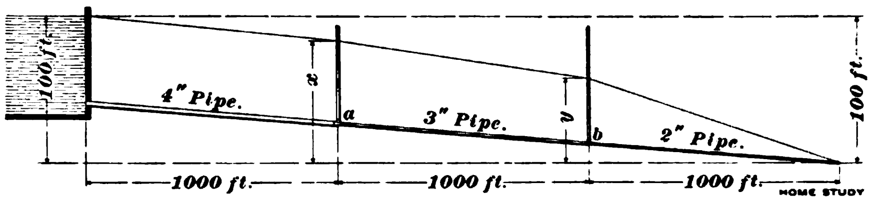
$$Q^2 = \frac{5.36 \times y \times 2 \times .000476}{25}, \qquad (f)$$

from which $x = 97.31$ and $y = 86.08$. The head absorbed in producing the flow through the 4-inch pipe is, therefore, $100 - x = 100 - 97.31 = 2.69$ feet, and the velocity of the flow in this pipe is

$$v_1 = 2.315\sqrt{\frac{2.69 \times 4}{.025 \times 1{,}000}} = 1.51 \text{ ft. per second.}$$

In the same way, the head absorbed in producing flow through the 3-inch pipe is $x - y = 97.31 - 86.08 = 11.23$ feet, and the velocity of flow is

$$v_2 = 2.315\sqrt{\frac{11.23 \times 3}{.025 \times 1{,}000}} = 2.69 \text{ ft. per second;}$$



and for the 2-inch pipe the head is $y = 86.08$ feet, and the velocity

$$v_3 = 2.315\sqrt{\frac{86.08 \times 2}{.025 \times 1{,}000}} = 6.07 \text{ ft. per second.}$$

From these values of the velocity, we get the quantity flowing through each of the pipes. For the 4-inch pipe we have

$Q = a_1 v_1 = .08727 \times 1.51 = .1318$ cu. ft. per second;
for the 3-inch pipe,
$Q = a_2 v_2 = .04908 \times 2.69 = .1320$ cu. ft. per second;
and for the 2-inch pipe,
$Q = a_3 v_3 = .02182 \times 6.07 = .1324$ cu. ft. per second.

The difference in these values of Q is due to the fact that the decimal values used have been only approximate; the result, however, is practically correct, and shows that under the assumed conditions the discharge is about .132 cubic foot per second.

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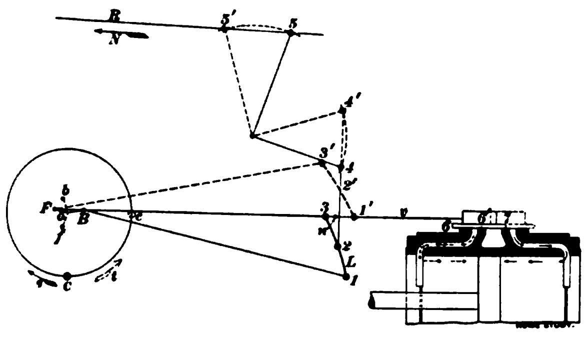
(299) (*a*) How does the reversing gear of a locomotive work? Please explain by aid of drawings. (*b*) What are the main principles of the gas or gasoline engine? A. E. S., Dayton, Ohio.

ANS.—(*a*) In the accompanying sketch, the various parts are shown in such positions as to render the explanation as clear as possible without affecting the principles involved; the cylinder has been brought towards the crank so as to save space in the illustration. In American locomotives, rockers are always used. The rocker, however, in no way alters the method of reversing; we merely set the eccentrics differently, placing each eccentric 90° − angle of advance *behind* the crank instead of 90° + angle of advance *ahead* of it. The terms *ahead* and *behind* are used with reference to the direction of the crank's motion. Also, the center line of the crank is always a couple of inches or so below axis of cylinder in actual practice. In the sketch, F is the fore, and B the back eccentric, $F3$ and $B1$ the fore and back eccentric rods, ($F3'$ and $B1'$ being their position in back gear). The crank is shown on the bottom quarter with the steam entering the front port and driving the piston backwards (to the left in the sketch) thus rotating the crank in the direction of arrow s, and causing the engine to run forwards. If now, while the crank is in this position, the reach rod R—which extends to the reverse lever in the cab

and is under the control of the engineman—is pulled in the direction of the arrow *N*, the link *L* will be lifted upwards and assume the dotted position, thus bringing the valve directly under the control of the back eccentric *B*, moving the valve to the right, as shown dotted, and uncovering the back port, the steam edge of the valve *6* being brought into the position *6'*. Steam will then enter the back port as shown by the dotted arrows and move the piston forwards (to the right) and rotate the crank as per arrow *t*, making the engine run backwards. In fore gear, certain of the parts are marked *1*, *2*, etc. In back gear, these same parts are marked *1'*, *2'*, etc. The end of the valve rod *v* carries in its back end a block which slides up and down in the link, as the latter is lowered or raised. Thus, as the link comes into the dotted position, the block, and therefore the rod *v*, is gradually pushed to the front end, thus uncovering the back port. Now, as regards the crankpin on the other side of the engine; it will, if the right crank leads, be on the dead center *c*, the piston being at the end of the stroke. It will be seen at once that the piston can only move *one way*, whichever direction the engine is to run in, and therefore the valve ought not to shift when the link is raised; if the valve gear is set correctly, the front port will be open the required amount of lead. Now *f* and *b* are the



positions of the fore and back eccentrics, and on measuring from *f* or *b* with eccentric rod length, the end of valve rod *v* (that is, the top of link at *3*) will be found at *n*. If, now, the valve be moved to the right a distance equal to *3n*, there will be found to be a certain small amount of port opening known as the lead, mentioned above. Since *fn* is the same as *bn*, it makes no difference whether the link is lifted up or down. In actual work this is practically true, also. (*b*) See article in Home Study Magazine for December, 1897, entitled, "The Gas Engine."

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(300) We wish to light our one-third of a mile (1,760 feet) bicycle track for night racing. What kind of, and how many, lights would you recommend us to use? How should these lights be placed?
R. B. G., Salina, Kan.

Ans.—As the details of the track are not mentioned, only general information can be given. Twenty arc lights may be placed on the inside edge of the track, at 88-foot intervals, by which disposition the lights are out of the line of vision of the racers. With current at 10 cents per kilowatt hour, the cost will be about 95 cents an hour for 2,000-candlepower lamps, and 75 cents an hour for 1,200-candlepower lamps. To this must be added the cost of attendance and new carbons. In case arc lights are undesirable, 160 sixteen-candlepower incandescent lamps may be used. When spaced 22 feet apart on each side of the track, a very agreeable illumination is furnished, provided the lamps are sufficiently elevated. The cost of running this number of incandescent lamps, with current at the same price, will be about 80 cents an hour. This does not take into account the renewal of broken lamps. The cost of this latter installation will depend greatly upon the cost of posts and labor.

***

(301) I enclose a couple of etchings of car axles. Will you kindly give your opinion of the nature of the materials these axles are made from, giving a rough approximation of the amount of steel in each?
A. J. F., Canton, Ohio.

Ans.—The etchings have been made from a photograph, and the markings are so indistinct that it is impossible for us to determine the materials composing the axles. We do not think that any one could do so.

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(302) (*a*) Does a dynamo, when generating electricity, gather it from the air? (*b*) Does the location of a dynamo, in regard to the supply of air, influence the generating powers of the dynamo, and consequently the illuminating power of the lights? (*c*) Will a dynamo, when placed in a vacuum, generate electricity? A. M., Port Richmond, N. Y.

Ans.—(*a*) We presume that you refer to frictional, or static, electricity, which is seen in the air in the form of lightning, or which may also be observed from belting. Dynamic electricity is not produced by friction but by *induction*. What we mean by induction is this: If a wire is being swung past either pole of a magnet so as to cut the magnetism which apparently emerges therefrom, it will be found to be maintaining a difference of potential or electrical pressure at the ends of the wire; so that, if the two ends of the wire are connected together by another wire, thus completing the circuit, a current of electricity will pass around this circuit. This current will be very small, to be sure, but, when many such wires are connected in series, and made to pass at a great velocity in front of the pole faces of a magnet, a very high pressure can be induced and maintained, as in the modern dynamos. (*b*) Yes: the cooler the dynamo for a given output, the greater the efficiency. Dry air, only, should be allowed to come in contact with the machine, as moisture weakens the insulation. In order that the lamps may burn at a proper brilliancy, the voltage of the machine should be adjusted by the field resistance box. (*c*) If a dynamo were run in a vacuum, it certainly would generate electricity, as the action of the dynamo is not affected by atmospheric conditions, except as to cooling and friction effects. Its maximum output or capacity would be considerably lower, however.

***

(303) (*a*) How far can the voice be distinctly heard over a well constructed telephone line made with No. 12 B. W. gauge (about No. 10 B. & S.) galvanized-iron wire, with grounded circuit? (*b*) What are the advantages of a metallic circuit? (*c*) What are the advantages of copper over iron wire? (*d*) Can you refer me to a book on telephones and their construction? A. H. F., Galiad, Texas.

Ans.—(*a*) The speaking distance depends on the excellence of the instruments and the location of the line—conditions which make it difficult to answer the general question by a definite number of miles; but it would hardly be advisable to construct a

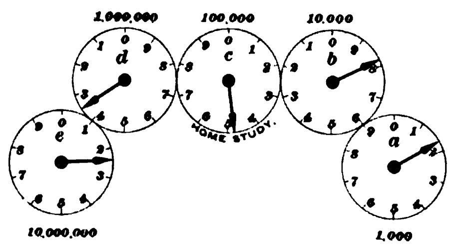
grounded circuit, with the overhead wire of the size mentioned, for a distance greater than 50 miles. (*b*) A metallic circuit, or a system of metallic circuits, is entirely insulated from all other electrical systems, including other telephone circuits; grounded telephone circuits; lighting circuits, which generally carry a slight ground, yet large enough to affect telephone circuits; and railway circuits, which are completely grounded, and carry enormous currents. Although a grounded telephone circuit may be in connection on one side only, with these various circuits enumerated, and at first sight may not appear to offer a path or outlet to any of these circuits, yet, on account of leakage currents and imperfect insulation of the line, the telephonic action is sometimes seriously interfered with. Another advantage of a metallic circuit, which may be considered by some as more worthy of notice, is the opportunity afforded of transposing the wires, and thus counteracting the induction effects from other telephone lines (apparent from cross-talk), as also the induction effects from telegraph lines and railway or lighting mains, especially alternating-current conductors, the induction effects of which cause disagreeable humming and noises in the receivers, or false rings or signals. A metallic circuit is also more convenient for testing for faults and locating troubles. (*c*) Higher conductivity, slightly less induction, and resistance to climatic action. Unalloyed copper is seldom used in telephone practice, but is combined with some other metal to give it greater tensile strength. Silicon is much used for this purpose, the resulting composition being called *silicon-bronze*. (*d*) "Telephones: Their Construction and Fitting," by F. C. Allsop, 1897 edition, sold by The Technical Supply Co., Scranton, Pa.

***

(304) I desire to have a correct diagram and reading of the Thomson Recording Wattmeter, built by the General Electric Co., for 220-volt service. I also wish to know how to read the meter built by the Thomson-Houston Co. for 115-volt service, alternating-current incandescent lighting.

J. R. J., Salt Lake City, Utah.

ANS.—The meters referred to are identical as far as reading is concerned. The appearance of the meter dial is shown in the figure. To read, begin at the



MULTIPLY BY 2

dial marked *1,000* and write the figures down as follows: The reading shown in the figure is, from dial *a*, *2*, or 200 watts; so write down the *2* and add two ciphers. On the next dial to the left, or *b*, the hand points to *8*; since the hand on dial *a* has just passed the zero mark, write down *8*; the reading is then 8,200. The hand on dial *c* is near *5*; but, as the reading of *b* was *8*, it is certain that the hand on *c* has not passed *5*, and the reading of *c* should be *4*, so the reading now becomes 48,200. Dial *d* is easy to read because the hand is midway between *3* and *4*; so the next figure is *3*, and the reading is now 348,200. On dial *e* the hand is near *2*; and, since the hand on *d* is past the zero mark, the reading is *2*, and the final reading of the dials is 2,348,200. This is *not* the meter reading, however, as it must be multiplied by the meter constant indicated by the words "multiply by *2*" marked on the dial face. $2,348,200 \times 2 = 4,696,400$, which is the meter reading. Never read a meter from left to right, or the result may be confusing.

***

(305) Is there a generally accepted standard for bolt heads and nuts, and, if so, what is it? Surely the Franklin Institute standards are not adhered to in general practice, and the old standard for the height of a nut is followed by no one. We have tried to find out what the general practice is by writing to manufacturers, but the answers received have been evasive and unsatisfactory. Does the standard for unfinished heads and nuts apply also to finished nuts?

C. H. S., Hampton, Va.

ANS.—The standard most generally used for rough nuts is known as the "manufacturer's standard," which, as you say, is different from the Franklin Institute standard. Tables of the manufacturer's standard sizes are given in the pocket companion published by the Carnegie Steel Co., of Pittsburg, Pa.; also in a little book, "Useful Information for Business Men, Mechanics, and Engineers," published by Jones & Laughlins, of the same city. It is probable that the Franklin Institute standard is more generally used for finished than for rough nuts.

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(306) I have an engine that I bought for a 20-horsepower engine. It uses steam at 120 pounds gauge; its length of stroke is 12 inches; the diameter of cylinder is 9 inches; it cuts off at $\frac{3}{4}$ stroke; and makes 225 revolutions per minute. I have figured the horsepower to be 81. Please tell me what the probable indicated horsepower is.

W. E., Kurtz, Minn.

ANS.—Under the conditions given, the engine would develop from 80 to 85 indicated horsepower.

***

(307) (*a*) What is meant by the *tensile strength* of a rope? (*b*) Is there any rule for determining the tensile strength of a steel-wire rope? (*c*) What is a *thermal unit*? W. S. F., Collinsville, Ill.

ANS.—(*a*) By ultimate tensile strength of a rope is meant the maximum pull it is able to sustain before rupture. (*b*) The working strength of a steel-wire rope of best quality may be found approximately by the following formula:

$$P = 1,000\ C^2,$$

in which P = working load in pounds;
C = circumference of rope in inches.

The rope is supposed to consist of 7 strands, 19 wires to the strand. (*c*) A British thermal unit is the amount of heat necessary to raise the temperature of 1 pound of water 1 degree Fahrenheit.

***

(308) Is it wise, from the standpoint of economy, to make steam in a 150-horsepower boiler for supplying a 20-horsepower steam engine? What about the amount of fuel used and the wear on the boiler?

B. E. McG.

ANS.—It is not. As you imply, there will be much unnecessary wear and tear. Suppose, for the sake of illustration, that the grate and heating surfaces are exactly proportional to the horsepower of the boiler; then, bearing in mind that all plates, tubes, etc. are being scaled up all the time; that stays and braces are undergoing their gradual deterioration; that grate bars are being slowly burned—all of which wear and tear will necessitate at *some* time a corresponding amount of labor during repairs—we see that we incur $\frac{150}{20} = 7\frac{1}{2}$ times as much of all this as is necessary. True, the boiler won't need forcing so much to do a given amount of work, but this will not save much in the deterioration of its parts. As regards fuel, a certain amount must always be on the grates, whatever may be the supply of steam

required. The grates must be kept covered; so there a loss occurs. If such a boiler were used, it would be advisable to "cut out" part of the grate, that is, cover it with firebrick. The case as proposed seems, in fact, to be precisely analogous to that of employing a consolidation engine to haul an inspection train.

***

(309) What size of steel wire, suspended between two trees 220 feet apart on opposite sides of a river, will safely carry a load of 400 pounds?

R. T. F., Alden, Iowa.

ANS.—You do not state what sag to allow for when the load is in the middle of the span. With this given, the diameter of the wire may be figured from the following formula:

$$d = \sqrt{\frac{12a(a^2+2h^2)Lr + 2\sqrt{h^2(a^2+h^2)L^2S^2 - 72a^3h^2(a^2+2h^2)L^2r^2}}{\pi[h^2S^2 - 36a^2(a^2+4h^2)r^2]}}$$

in which d = diameter of the wire in inches;
a = one-half the span in feet,
h = sag in feet;
L = load in pounds;
S = permissible stress, in pounds, per square inch of wire section,
r = weight in pounds of a cubic inch of the wire.

Taking $S = 25{,}000$ pounds, $r = .283$ pound, and, assuming the sag (h) to be 10 feet, we have $a = 110$ feet. These values substituted in the above formula give $d = .351$ inch.

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(310) I enclose herewith two diagrams of three-point switch turnouts; standard-gauge tracks, with third rail for narrow-gauge tracks. Please give formulas for ascertaining the frog angles and numbers for frogs A and B in both cases to match the frogs Nos. 7 and 9 as shown and given in the diagram; also give frog distances for frogs A and B in both cases. J. W. L., Bluff City, Tenn.

ANS.—This question is too comprehensive for these columns. The subject will be dealt with in an early article in HOME STUDY MAGAZINE.

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(311) (*a*) What is the rule for giving the necessary sag for copper wire (hard drawn) weighing 300 pounds to the mile, poles 50 yards apart, minimum temperature 55° F. below zero, maximum temperature 110° F. in the shade? (*b*) What is the rule for finding the breaking stress of hard-drawn copper wire? (*c*) Why is copper wire stronger when hard drawn than when not so done? (*d*) Has hard-drawn copper wire the same conductivity as soft-drawn copper wire, weight for weight?

IGNORAMUS.

ANS.—(*a*) The following formula gives the necessary sag for a hard-drawn copper wire:

$$h = \frac{W \times L^2}{8t}$$

in which W = weight of 1 foot of wire;
L = length of span in feet;
t = tension of wire (when in position) in pounds;
h = sag in feet.

The breaking stress of hard-drawn copper wire is 63,000 pounds per square inch, but only one-third of this is used, t, therefore, should not exceed 21,000 pounds per square inch. After the wire has contracted to its minimum of length, under the action of the lowest temperature, the limit of tension t must not be exceeded. (*b*) As the breaking stress is 63,000 pounds per square inch, the breaking stress of a hard-drawn copper wire is found by multiplying its sectional area in square inches by 63,000 pounds. (*c*) The metal in a hard-drawn copper wire is more compressed than in an ordinary copper wire; of two wires of the same diameter, the hard-drawn one will, therefore, so to say, have more metal with which to withstand any stress that may be put upon it. (*d*) An annealed copper wire, 1 foot long and weighing 1 grain, has a resistance of .2041 ohm, while a hard-drawn copper wire of the same length and weight has a resistance of .2083 ohm.

***

(312) I am putting in a plant of two return tubular boilers. They will be separated by a 24-inch wall. They are 72 inches diameter by 18 feet long, and contain seventy 4-inch tubes, they are to be fired with wood. The water to be used contains a considerable amount of salt and a good deal of solid matter. Is it advisable to have a steam drum and a mud drum on each boiler? F. A. R., Donaldsonville, La.

ANS.—We would advise you not to use a mud drum at all, but to try and remove the solid matter from the water as thoroughly as possible, before pumping it into the boiler. A filter can be used to good advantage for removing the solid matter held in suspension in the form of mud; if the water contains much lime in solution, a feed water purifier should be used. The salt cannot be readily separated and in order to get rid of it the boiler must be blown off at frequent intervals. In regard to the use of a steam drum, it would probably be better to have a separate dome on each boiler, dry-pipes properly arranged are better than either a steam drum or steam domes.

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(313) (*a*) What str
subjected to, and ho
the expansion of ca
pipe, per foot of leng
boiler grate are worn
and cast-iron bars su
the bars above or b
more injurious to th
the dampness of the
test be *always* relied
for cracks?

ANS.—(*a*) The principal stress to which a crankpin is subjected is bending, due to the thrust of the connecting-rod. It has been found in practice, however, that when a pin is calculated for strength alone it will be too small to run well and not wear rapidly or heat; for this reason, crankpins are generally calculated to give a bearing surface for the brasses that will bring the pressure per square inch between the pin and the brass below a certain standard, depending on the speed at which the engine runs. (*b*) The expansion of a steam pipe per foot of length depends on the temperature of the steam, which varies with the pressure. Cast iron expands about .000006 foot, and wrought iron about .000007 foot, per foot of length for each increase of 1 degree Fahrenheit in its temperature. If the pipe is put up at a temperature of 60°, and is then subjected to a steam pressure of 100 pounds gauge, the increase in its temperature will be about 278 degrees, and the expansion per foot of length for cast iron will be $.000006 \times 278 = .001668$ foot, and for wrought iron $.000007 \times 278 = .001946$ foot. This is about $\frac{1}{50}$ inch for cast iron and $\frac{1}{40}$ inch for wrought iron. (*c*) It would probably be best to put the bars above the plugs in most cases. (*d*) Yes. It requires a practiced ear though. When cars are tested at intervals during a journey, for broken tires, the "wheel tapper," as he is called, relies *solely* on his ear. He would not have nearly enough time for the job, if he attempted to find cracks by eye.

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(314) (*a*) Will a violin string vibrate if there is no air round it? (*b*) Kindly give me a receipt for bluing steel, one that you know has done good work.

W. G. K., Columbiana, Ohio.

ANS.—(*a*) Certainly; there will be no sound heard, however. The friction between the bow and the

strings sets the latter in motion. If, however, there is no air for *them* to set vibrating, we shall hear no sounds. (*b*) Dissolve (1) 4¼ ounces of hyposulphite of soda in 1 quart of water and (2) 1¼ ounces of acetate of lead in one quart of water. Mix the two solutions together, and bring to a boil in a porcelain dish or a stone pot. Clean the articles free from grease or other coatings, warm them, and then apply the above mixture while hot, smearing it on with a small piece of sponge tied to a stick. When the right color develops, wash and wipe dry, finishing with boiled linseed oil. The above is said to be a good method. We cannot vouch for it from experience, however, but can suggest that you try it.

***

(315) (*a*) In riveting machinery, what is the *closing* pressure per square inch of rivet area, according to best practice? (*b*) In a plate-closing riveter, how is the required pressure determined for the plate-closing device? X. Y. Z.

ANS.—(*a*) For driving ordinary rivets of best quality iron or very soft steel, at bright red heat, in good smooth holes, 85 tons per square inch of rivet area is considered an average. Long rivets, lower temperatures, and bad holes call for greatly increased pressures. (*b*) On the pressure required for the plate-closing device, very meagre information exists. In fact, the value of a plate closer in riveting machinery is a matter of dispute, especially as it is arranged in most riveting machines. The prevailing opinion seems to be that, when the holes are good, a plate closer may well be dispensed with except with very heavy plates. As, however, the function of the plate closer is to keep the plates together tight enough to prevent the rivet from "washering" between them, till its body has so swelled as to completely fill the hole, the pressure on the plate closer should be kept on full, and equal to the pressure on the rivet at the commencement of the forming of the head, before it is transferred to the riveter. This pressure is estimated at about 50 tons per square inch.

***

(316) Can you tell me how to straighten a large celluloid set square, or triangle? It has become badly warped. O. R., Sherman, Texas.

ANS.—When a celluloid triangle has become warped, you can make it flat again by placing it between two warm surface plates, and leaving it there until the plates are cold. The writer remembers having straightened large and badly warped triangles, by simply warming them and leaving them over night under pressure between two flat boards. When straightened, however, it is often necessary to true up the angles. All triangles, straightedges, and T squares require attention at times; they get out of shape, no matter of what material they are made, whether wood, vulcanite, or celluloid. Never lay them down where the sun can shine directly upon them, and don't put them away near any heat supply, such as a steam pipe. Some draftsmen swear by one material, others by another. The writer knows from experience that the majority of good draftsmen use transparent celluloid triangles; their transparency is a great advantage, they wash easily in cold water and soap, and, if taken reasonable care of, they are as reliable as any, except steel ones, and the latter are rarely used, because they soil the paper badly, and are heavy and very uncomfortable to handle.

***

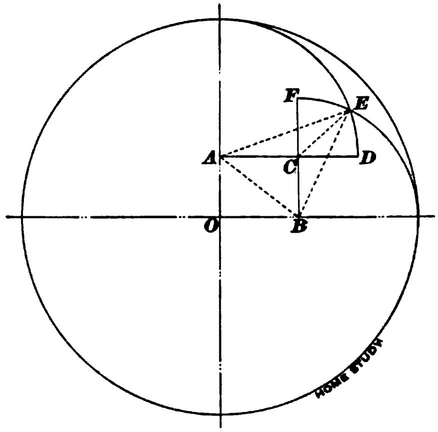
(317) Will you kindly give a receipt for mending broken glassware, such as beakers, dishes, and other chemical ware? H. V., Oakland, Cal.

ANS.—Either of the following will give satisfaction: (1) Dissolve from 5 to 10 parts of pure dry gelatin in 100 parts of water. Add to this solution 10% of a concentrated solution of bichromate of potash. Keep the liquid in a dark place. After applying, expose the articles to the light. (2) Fuse together in an iron pot 2 parts of gum shellac and 1 part of Venice turpentine, being careful to keep the lid on during the process, as the turpentine is very inflammable. When nearly cool, form the mass into sticks of convenient size. When wanted, melt a portion near a gentle heat.

***

(318) A horse is tied with a 100-foot rope to one corner of a 30 ft. × 40 ft. barn; over what area can he graze? C. D. C., Patalaska, Ohio.

ANS.—He can graze over ¾ of the circle whose center is *O*, ¼ of the circle whose center is *A*, and ¼ of the circle whose center is *B*; but these last two quadrants



overlap, and have the space *CDEF* in common. Hence, we must find the area of this space. Solving the triangle *ABC*, we get

angle $BAC = 36° \ 52' \ 11.6''$,

and angle $ABC = 53° \ 7' \ 48.4''$.

Solving the triangle *ABE*, we get

angle $BAE = 57° \ 7' \ 17.8''$,

and angle $ABE = 78° \ 27' \ 47''$.

Therefore,

angle DAE = angle $(BAE - BAC) = 20° \ 15' \ 6.2''$,

and

angle FBE = angle $(ABE - ABC) = 25° \ 19' \ 58.6''$.

Now,

area (ECD) = sector (EAD) − triangle (EAC) = 865.975 − 484.603 = 381.372;

area (FCE) = sector (FBE) − triangle (CBE) = 795.858 − 385.090 = 410.768.

Hence,

area $(CDEF) = 381.372 + 410.768 = 792.140$ sq. ft.

Then, the area grazed over =

$\left[\frac{3}{4}(100)^2 + \frac{1}{4}(70)^2 + \frac{1}{4}(60)^2\right]$ − area $(CDEF)$ = 30,237.83 − 792.14 = 29,445.69 sq. ft.

***

(319) I send you drawing of a 70-volt, 100-light dynamo. The armature is wound with No. 5 wire, 56 parts, and the shunt fields are wound full and have 95 pounds of No. 12 wire on each pole. The compound has 20 turns of No. 3 wire on each pole. The speed is 1,400 revolutions per minute. Will you kindly tell me what change in voltage it would make if I rewound the shunt fields full with No. 10 wire and did not change the speed or other windings? A. K., Fitchburg, Mass.

ANS.—You have not given sufficient data for an exact determination of voltage when using No. 10 wire. To enable the problem to be solved with any degree of accuracy, the dimensions of the field cores or the number of turns of wire should be given, and also the material of which the field cores are made.

From the data given, and by assuming some of the dimensions not given, we should conclude that the voltage of the dynamo would be increased to about 80 volts by the change in the winding.

***

(320) Kindly inform me how to determine the amount of heat conducted away, in a given time, from a liquid metallic bath whose temperature is 800° F., by a copper rod ¾ inch diameter by 30 inches long, the rod having one end in the bath, and the other connected to copper plates of such size as to remain at the temperature of the room.

C. L. J., Jersey City, N. J.

ANS.—The proper way to make the determination is by actual experiment as follows: First determine the rate at which the molten metal will cool with the copper rod absent. Then insert the rod, and note the difference in the rate of cooling. The difference between the two results will show the cooling effect of the rod; so that, knowing the specific heat of the molten metal and its weight, the heat carried away by the rod can be calculated. Several determinations should be made and the average taken.

***

(321) Will you please inform me how much power it will require to propel a flat, scow-shaped boat, 10 feet wide by 40 feet long, by means of two side wheels, at a rate of 6 or 8 miles per hour? The carrying capacity is to be 20 tons. Kindly explain the method of estimating the above.

A. R., Pueblo, Col.

ANS.—The exact amount of power required to propel a vessel at a given speed cannot be deduced very readily from the elementary principles of mechanics. Instead, we must rely upon empirical rules, based upon the actual performances of vessels. An empirical rule often used is

$$H = \frac{S^3 \times \sqrt[3]{W^2}}{k},$$

where H = indicated horsepower;
W = displacement of the vessel, in tons;
S = speed of vessel, in miles per hour;
k = a constant based upon the actual performance of similar vessels.

Since you have not given the draft, we will assume it to be 2 feet 6 inches. Then, your boat being rectangular, the displacement is

$$\frac{10 \times 40 \times 2.5}{35} = 29 \text{ tons, nearly.}$$

Letting $S = 7$ miles, and $k = 130$, and substituting these values in the above formula, we have

$$\frac{7^3 \times \sqrt[3]{29^2}}{130} = 25 \text{ horsepower, approximately.}$$

***

(322) (*a*) What is the process, in detail, by which copperplates for printing purposes are produced from photographic negatives? (*b*) What are the principal commercial uses of galvanoplastic work? (*c*) Is not most small statuary—clock ornaments and articles of that kind—produced by the galvanoplastic process?

F. P. W., Delaware, O.

ANS.—(*a*) The negative for the half-tone process is made by the insertion of a grating between the lens of the camera and the sensitized plate. The grating consists of two plates of glass that are ruled, by means of a diamond, in parallel lines at an angle of 45° with the edges of the plate. These two plates are placed so that the ruling on one plate is at right angles to the ruling on the other. The position of the grating is immediately in front of the sensitized plate, usually about $\frac{1}{16}$ inch away. The copperplate is coated with a sensitive enamel composed of glue, and sensitized with a solution of ammonium bichromate with excess of ammonia. After the plate receives a photographic impression from the negative by means of the ordinary photographic printing process, it is developed, washed, and the glue is "burned" hard by holding over a gas or oil stove. The impression is then etched on the copper with a solution of perchloride of iron to a depth slightly less than the thickness of ordinary writing paper. (*b*) Galvanoplasty is another term for electrotyping. The term also applies to the production of bronze statuary by electrodeposition of the metal on a plaster model; the model being afterwards broken up and removed. (*c*) Clock ornaments are usually made of spelter. The process called *slushing* consists of pouring the hot spelter into a brass mold, twirling the mold about until the metal nearest the mold is set, and pouring out the surplus metal. The result is a hollow casting.

***

(323) Kindly give me all the necessary rules and formulas for designing "solenoids."

F. T. S., Allegheny, Pa.

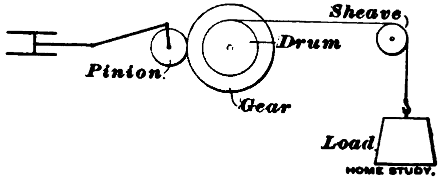
ANS.—The rules and formulas for designing a solenoid are the same as those which apply to the electromagnet. We have not the space to devote to this subject in the inquiry columns. Such formulas and information as are required for solenoid design may be found in "The Electromagnet" by Sylvanus P. Thompson, price $1.00. It may be obtained from The Technical Supply Co., Scranton, Pa.

***

(324) Is the following formula correct for ascertaining the maximum load that a derrick engine can lift: maximum load (or effective pull at the hook) = steam pressure × piston area × twice the stroke × gear ratio. I notice in "Mines and Minerals" for May, 1898, page 453, that Mr. Jacobs makes use of a formula by which he obtains a much larger pull than I do. He does not take into account the fact that the load has to be raised, while mine does, I think—the result being in foot-pounds.

W. H. W., Toledo, O.

ANS.—You cannot determine the hoisting power of an engine by the formula given. Mr. Jacobs, in the answer to which you refer, is correct in the method he uses to arrive at the dimensions of the required engine. A hoisting engine should always be double cylindered, so that if one is on the dead center, the other will be in a position favorable to lifting the load. This fact, Mr. Jacobs was careful to explain. In order to lift the load the force exerted by the steam, acting—through the piston-rod and connecting-rod—at the crank pin, must be sufficient to overcome the frictional resistances of the gearing, rope, and sheave, and to transmit a pull at the hook slightly in



excess of the load. The *power* of an engine bears no direct relation to the *dead load* it can lift. It is a question simply of *leverage*, and for that reason hoisting engines are not fitted with heavy fly wheels, as are engines used for driving machinery. In the latter case the engine is always started under a very light load—resistance of line shafting, countershafting, belts, etc. When it attains its regular working speed, the governor either throttles the steam or varies the cut-off, so keeping the velocity practically constant. When a machine is "put on" the momentum of the flywheel prevents the speed of the engine from being materially or suddenly reduced. With a hoisting engine it is different—the start having to be made under full load; for which reason two cylinders are used and the cranks are set at right angles.

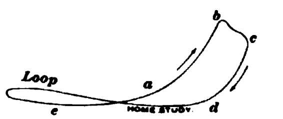
Of course, the horsepower of the engine is all *used;* for example: If the indicated horsepower of the engine is 100 and its efficiency is 85 per cent., then 85 horsepower are delivered to the hoisting mechanism. If the hoisting mechanism has an efficiency of 75 per cent. then the horsepower left for raising the load is $85 \times .75 = 63.75$. That is

The power used in overcoming resistances in the engine =	15 H. P.
The power used in overcoming resistances in the gearing, etc. =	21.25 H. P.
The power used in raising the load =	63.75 H. P.
Total,	100.00 H. P.

***

(325) I should be pleased to learn your explanation of the loop in the cards taken from air pumps of steam engines. The loop is to be found in the cards from many vertical air pumps, which pumps are single acting and have three sets of valves—foot, bucket, and head valves. A. F. H., Boston, Mass.

ANS.—If point *c* in the diagram is the beginning of the outward stroke, it is seen that along part *d* the pressure is gradually diminishing until the end of the stroke is reached; before the piston begins its return movement the air contained in the cylinder is very likely, for a short time, exposed to the cooling influence of the cylinder walls, in which case the pressure would fall, and the return stroke begin with a reduced pressure that would gradually rise along part *a* up to point *b*, when it would be sufficient to open the valves, with a resulting decrease in pressure up to the point *c*.



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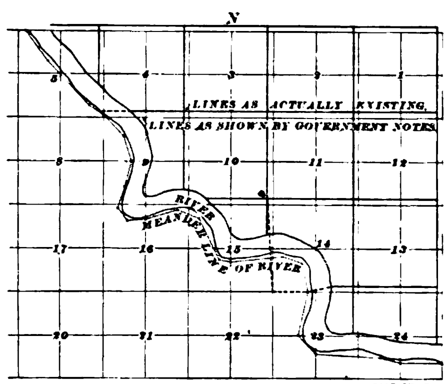
(326) (*a*) What is the percentage of gas and air used in gas engines? (*b*) What is the pressure in the cylinder at the moment explosion takes place? (*c*) I enclose sketch of gas-engine cylinder in which the dimensions are given in millimeters. What would be the power of such an engine receiving an impulse every other stroke? (*d*) What weight of balance wheel would you advise and what diameter? (*e*) The cylinder is to be made of seamless brass tubing 19 mm. inside diameter, 2.3 mm. thick, and 80 mm. long; what would be its bursting strength? (*f*) How many degrees should the crank be below center when the gas is ignited? (*g*) You will notice that in the sketch I show the air compressed from about 65 mm. to 12 mm: will that be too much? (*h*) Can you tell me how to make gold-colored soft solder? (*i*) What can I put in potato juice to prevent it from smelling bad and souring. W. C. B., Keokuk, Iowa.

ANS.—(*a*) For ordinary coal gas, 1 volume of gas to 8 volumes of air. (*b*) This pressure varies from 140 to 200 pounds per square inch; your engine will give about 150 pounds just after explosion. (*c*) The engine should run at from 750 to 1,000 revolutions per minute. At 750 revolutions the power will be approximately $\frac{1}{38}$ horsepower and at 1,000 revolutions $\frac{1}{30}$ horsepower. (*d*) Use two balance wheels, one on each side of the crank, of the following dimensions: outside diameter 7 inches, width of face ½ inch, depth of rim ½ inch. These flywheels, if made of brass, will give the weight required. (*e*) It is impossible to determine this quantity with any degree of accuracy, because of the peculiar nature of brass tubing. It would probably stand 2,000 pounds per square inch without bursting. (*f*) 20°. (*g*) Yes; compression is too great: make length of compression space one-half that of stroke for flame ignition and one-third for electric or tube ignition. (*h*) Soft solder should be colored after application. Either plate with brass, or if gold is desired, deposit copper first before placing in gold plating solution. We know of nothing that would color the solder in bulk, without making it too hard or unfit for use. (*i*) Add a little of Condy's red disinfecting fluid (a solution of potassium permanganate in water). We cannot, very well, give advice of this kind without knowing the use you intend to make of the potato juice.

***

(327) Will you kindly inform me as to the proper manner to proceed in retracing section lines as shown on enclosed sketch? The land south of the river was first sectionized and corners of fractional sections set on south bank of stream where the lines intersected it. The south bank of the river was also meandered from one of these corners to another. Some time after, by another man, the lands north of the river were surveyed. His notes indicate that he began on the south bank at these fractional corners and extended the lines thence. As the stones on the north side are both north and west of where they would be were this the case, it is apparent that it was not done this way. Now where is the line crossing the river? Is it a straight line between the nearest corners on opposite banks of the river as shown between sections 14 and 15, or is it projected straight on either side to the river bank and a straight line between these points, as shown between sections 14 and 23, or is it projected across from the north side till it meets the meander line, as shown between sections 4 and 9? F. T. L., La Junta, Colo.

ANS.—This is one of the problems encountered in the practice of surveying that is very difficult to solve satisfactorily in all cases. The surveyor must be guided largely by the conditions as he finds them and by the decisions of the courts in similar cases. In retracing the lines of the government surveys, he should adhere strictly to the infallible and inflexible rule that *the lines must be relocated in the positions where originally run when it is possible to do so,* regardless of any inaccuracies in the original lines, or of any considerations as to where they should be. It



should also be understood that the properties bounded by a non-navigable stream extend to the center of the stream, or *filum aquæ* as it is termed. The *filum aquæ*, or "thread of the stream," is midway between the lines of ordinary low-water mark, without regard to the depth of water or position of the channel. It is the boundary line for all properties limited by the stream. The lines between adjacent properties bordering on the stream on the same side terminate at the *filum aquæ*. Such lines are not properly considered as extending *across* the stream. If any such line is not at right angles to the general course of the stream, it is deflected at the meander line so as to extend from the meander line to the center of the stream at right angles to the stream's general course. The legal rule governing the case

has been stated as follows by the Chief Justice of the Supreme Court of Michigan: *Extend the line of division between the two parcels from the meander line to the center line of the river, as nearly as possible at right angles to the general course of the river at that point.* It will thus be seen that none of the three methods suggested in the question would be correct, except that the method indicated for the line between sections 14 and 23 might be correct in some cases. The lines of the government survey must be relocated in their true positions as originally run. These lines properly terminate in the meander lines on the respective banks of the river, from which intersections, the boundary lines should be extended at right angles to the stream, terminating at the center of the stream. If there are no meander corners, or starting corners for the lines of the more recent government survey on the north side of the river, it is our opinion that it would be proper to extend the lines of that survey as far as ordinary low-water mark.

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(328) (*a*) Will you please give instructions for charging magnets? (*b*) Are magnets that are built up in layers better than those made of a single piece of steel? (*c*) What kind of steel is best for magnets? (*d*) How long does a good magnet retain its magnetism? (*e*) In what numbers of HOME STUDY MAGAZINE are magnets or magneto-machines written up? H. A. H., Bellevue, Ky.

ANS.—(*a*) It is supposed that in the present instance the magnet to be charged is a horseshoe magnet. The magnetization may then be accomplished either by means of a permanent horseshoe magnet or an electromagnet; they are both used in the same manner. The horseshoe is fastened to a table, and an armature laid across its ends; the magnet is then placed at right angles to it with one pole on each leg near the end, and is stroked over it towards the curved part, then returned through the air and the stroke repeated, both sides being treated in the same manner. Ten strokes will complete the magnetization, and the polarity of either leg will be the same as the one with which it was in contact. An electromagnet charged with not less than 3 cells may be used in place of the steel magnet. (*b*) Yes. (*c*) Tool steel drawn to a straw color or a little lower. All shaping and filing must be done before magnetization. (*d*) Practically forever; though there is a gradual decrease in strength. (*e*) In the July, 1896, HOME STUDY MAGAZINE, there is an article entitled "Does the Magnetic Needle Point North?"; in the August, 1896, number, "Magnets"; in the November, 1897, number, "The Design of Hoisting Magnets."

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(329) Will you please let me know (*a*) What the discharge per minute is, in gallons, from the nozzle of a hose 700 feet long, 2½ inches in diameter, with 60 pounds pressure per square inch at hydrant, to which the hose is attached, the opening of the nozzle at discharge point being 1¼ inches in diameter? (*b*) What is the longest board 12 inches wide that can be placed in a room 18 ft. × 24 ft., the ends of the board being cut square, and such board to be laid flat on the floor? Please show how to work out both the above problems. P. W., Lake Linden, Mich.

ANS.—(*a*) A pressure of 60 pounds per square inch corresponds to a head of 60 ÷ .434 = 138.25 feet. A part of this head is absorbed in forcing the water from the hydrant through the hose to the nozzle, while the remainder appears at the nozzle as pressure, and acts to force the water through the nozzle and give the issuing jet its velocity. The part of the head absorbed in forcing the water from the hydrant through the hose, which we will call x, depends on the method of connection between the hydrant and hose, and the condition of the hose, whether rough or smooth, etc. We will assume that the connection is such that the loss from it may be neglected and that the hose is moderately smooth and straight; under these conditions the velocity of flow v_1 through the hose in feet per second may be expressed by the formula

$$v_1 = 2.315\sqrt{\frac{h_1 d}{f l}},$$

in which h_1 = head in feet;
d = diameter of hose in inches;
f = a coefficient depending on the character of the hose, its diameter, and the velocity of flow;
l = length of the hose in feet.

Under the assumed conditions, f may be taken as .03.

Substituting in the formula for v_1, we have

$$v_1 = 2.315\sqrt{\frac{x \times 2.5}{.03 \times 700}}. \qquad (1)$$

The velocity of flow v_2 through the nozzle in feet per second depends on its form and the pressure head h_2 at the end of the hose. The pressure head is equal to the head of 138.25 feet at the hydrant, minus the head x; assuming an average nozzle, the velocity v_2 is expressed by the formula

$$v_2 = .98\sqrt{2 g h_2} = .98\sqrt{64.32(138.25 - x)}. \qquad (2)$$

The quantity of water in cubic feet per second Q flowing through both the hose and the nozzle is the same, and is equal in each case to the area in square feet multiplied by the velocity in feet per second. The area of the hose is $(2\frac{1}{2})^2 \times .7854 \div 144 = .03408$ square feet, and of the nozzle $(1\frac{1}{4})^2 \times .7854 \div 144 = .01227$ square feet; therefore, $Q = v_1 \times .03408 = v_2 \times .01227$, from which $v_1 = \frac{Q}{.03408}$ and $v_2 = \frac{Q}{.01227}$. Substituting these values of v_1 and v_2 in equations (1) and (2), and squaring, we have

$$Q^2 = \frac{5.36 \times x \times 2.5 \times .00116}{.03 \times 700}. \qquad (3)$$

and $Q^2 = .9604 \times 64.32 \times (138.25 - x) \times .00015.$ (4)

Solving for Q, we have $Q = .308$ cubic feet per second, from which the discharge in gallons per minute is found to be $.308 \times 7.48 \times 60 = 138.23$ gallons. (*b*) See HOME STUDY MAGAZINE, May, 1897, Answers to Inquiries, No. 140, for a similar question and solution.

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(330) (*a*) What is the process of panning out gold in placer mining? (*b*) What is meant by "drop forging"? REX, Scofield, Utah.

ANS.—(*a*) See July number, Answers to Inquiries, No. 259. (*b*) Drop forging is a process of forging in which the metal is formed by being compressed between two dies. One of the dies forms a part of the anvil, while the other is attached to the hammer. The hammer used is generally a "drop hammer," that is, a hammer consisting of a heavy weight, which is lifted and then allowed to drop on the anvil.

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(331) Can you give me any information regarding the causes that tend to make an arc lamp flash? I. J., Brenham, Tex.

ANS.—Arc lamps flash because of poor regulation of the carbon-feeding mechanism, or because of a bad spot in the carbon.

***

(332) Can you give me or tell where I may find explicit directions for making a 12-inch electric fan which can be driven from one or two cells of a battery? G. H. B., Cleveland, Ohio.

ANS.—Write to the Leavitt Motor Co., Providence, R. I. They will sell you castings and all supplies for a battery fan, and furnish complete instructions.

(333) (*a*) Fig. 1 is a drawing of an elbow for a water pipe. The layout was made by our foreman. Every rivet hole was put in on the flat plate, and after the plates were rolled and put together the holes matched perfectly. The elbow is 10 feet in diameter on the inside; it is made of ⅜-inch plate, and the rivets are ⅞ inch in diameter, about 2-inch pitch. The ten sections of which the elbow is composed are alike, and are tapered so that the water in flowing through in the direction of the arrow will not strike

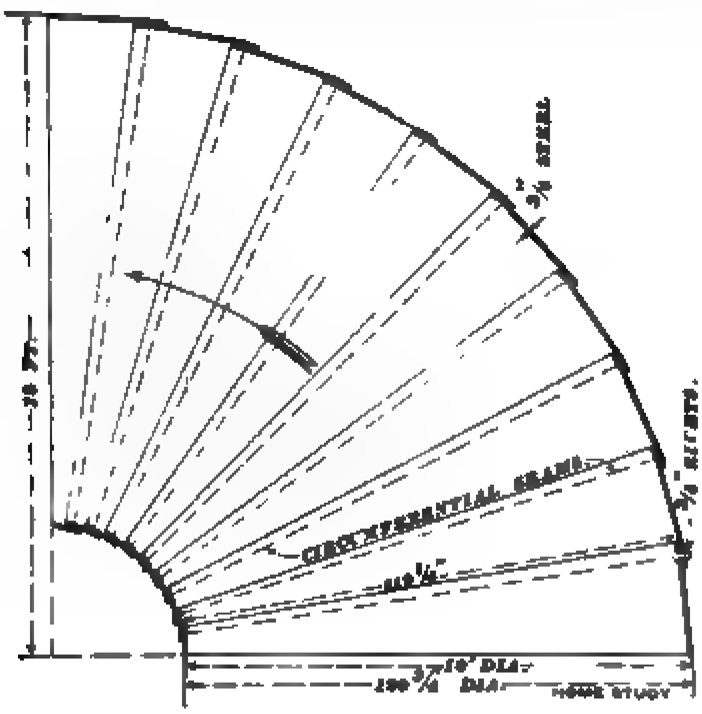
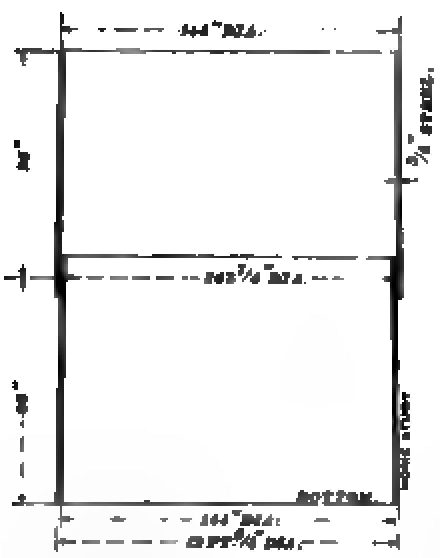


FIG. 1.



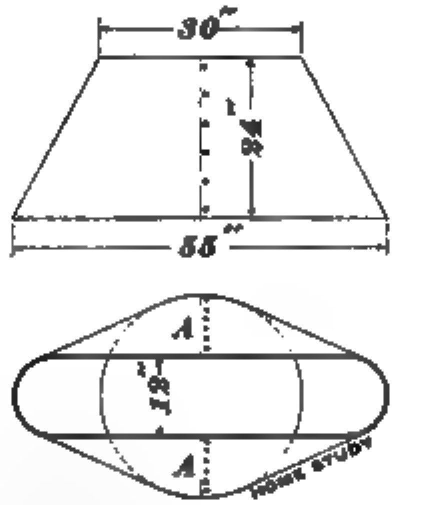
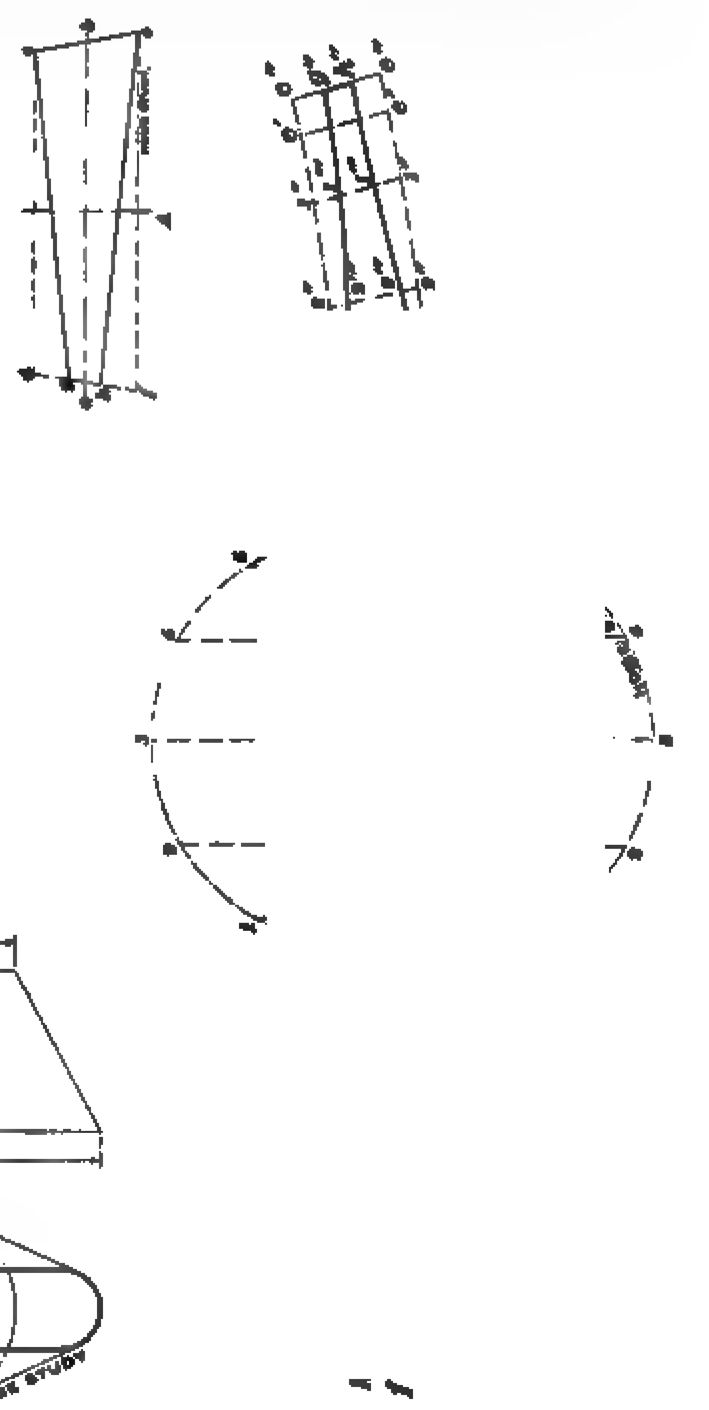


FIG. 2. FIG. 3.

the edges of the plates. How can the sections be laid out without the use of triangulation? (*b*) Fig 2 represents a smokestack. I want to make a layout of the two parts, without the use of triangulation; in large jobs like this one, the method of triangulation already described in HOME STUDY MAGAZINE has to be done with great accuracy, otherwise serious errors creep in. (*c*) Fig. 3 represents a piece of a stack to be made of 2 pieces, the seam being at *A*. Please explain the shortest and best method of doing this without triangulation. F. A B., Charleston, S. C.

ANS.—(*a*) Each section is a frustum of a cone with equally inclined bases. Draw an elevation, *A*, of one section, and draw a central section line *a b*. This central section is to be circular. The bases will be slightly elliptic Draw *c d* and *e f* parallel to *a b*. Now lay out the development of the right frustum *d c e f*, and take off the parts *c d g* and *e h f* in the following manner: Add another figure like *d c e f* onto *d* and also one onto *c e*. This will give the points *d'*, *f'*, and *c'*, *e'*, as shown in Fig. *B*. Draw a circular arc through *d'*, *d*, *c*, *c'*, and extend it a little beyond *c'*, and do the same through *f'*, *f*, *e*, *e'*. With center *i* and radius *i d*, describe a semicircle, and do the same with center *j* and radius *j f*. Divide each semicircle into a convenient number of equal parts, not less than 6, and draw perpendiculars to *a b* through all



the points of division, intersecting the diameter of each circle, as shown in *1'*, *2'*, etc. Draw *1'*-*1'*, *2'*-*2'*, etc., intersecting *g c* in *1''*, *2''*, etc. Set off *d' c''* so that the length of the arc *d' d c c''* will be the same as twice the length of the semicircle *d*-*3*-*c*. Set off *f' e''* so that the length of the arc *f' f e e''* will be the same as twice the length of the semicircle *f*-*3*-*e*. Divide the arcs *d' c''* and *f' e''* each into as many equal parts as the semicircles *d*-*3*-*c* and *f*-*3*-*e* were divided—6 in this example—in *1''*, *2''*, etc., and draw the lines *1''*-*1''*, *2''*-*2''*, etc. Make *1'' 1''' = 1'*-*1''*, *2''*-*2'' = 2'*-*2''*, etc. Also make *d' g'* and *c'' g''* each = *d g*, etc. Draw a curve through *g'*, *1'''*, *2'''*, etc. to *g''*, and another one through *h'*, *1'''*, *2'''*, etc. to *h''*, as shown The figure *g' g'' h'' h'* is the required layout. (*b*) See HOME STUDY MAGAZINE, August, 1897, Answers to Inquires, No. 279. (*c*) See Answers to Inquiries, No. 334 (*a*), in this number.

(334) (*a*) I would like to know how to lay out Fig. 1 in four sections, and (*b*) how to find the radius *C* in Fig. 2, also the chord *E*, and the dimension *D*.

W. B., Pittsburg, Pa.

ANS.—(*a*) The sides of this transition piece consist of 4 equal parts. Draw a top view or plan *A*, of one of the four equal parts, and an elevation *B*, of this part. The center line for both views is *a b*; and the conjugate center line of the plan is *b c*. Divide the quadrant *e-6* into a convenient number of equal parts, and divide the smaller quadrant *c d* into the same number of equal parts. Project the point *d* from the plan into the elevation *B* to *6'*. Draw *6-6'*, and *e c*, *B*, and continue them to meet in *f*. Draw projectors through all the points of division of both quadrants: *5-5*, *4-4*, etc., *A*, intersecting *b c* in *5''*, *4''*, etc., and intersecting *6-e* of *B*, in *5*, *4*, etc.; also intersecting *a c*, as shown. Draw a center line *e c*, *C*, for the lay-out. Make *e c*, *C*, = *e c*, *B*, and *e f*, *C*, = *e f*, *B*.

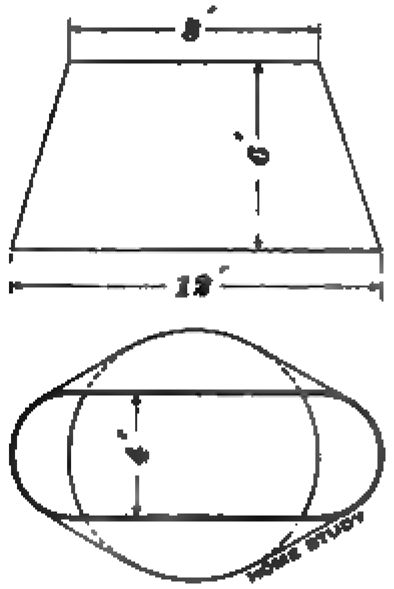
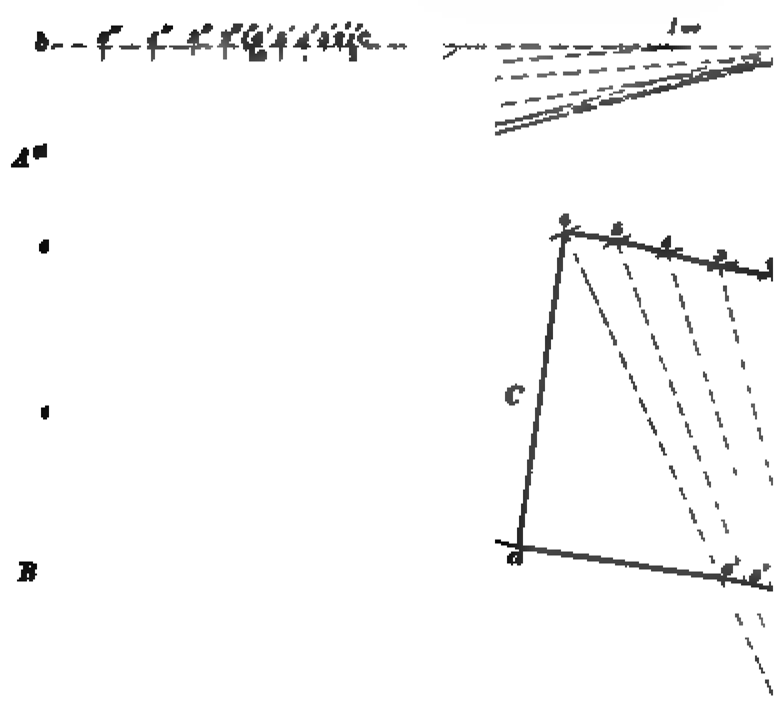


FIG. 1.

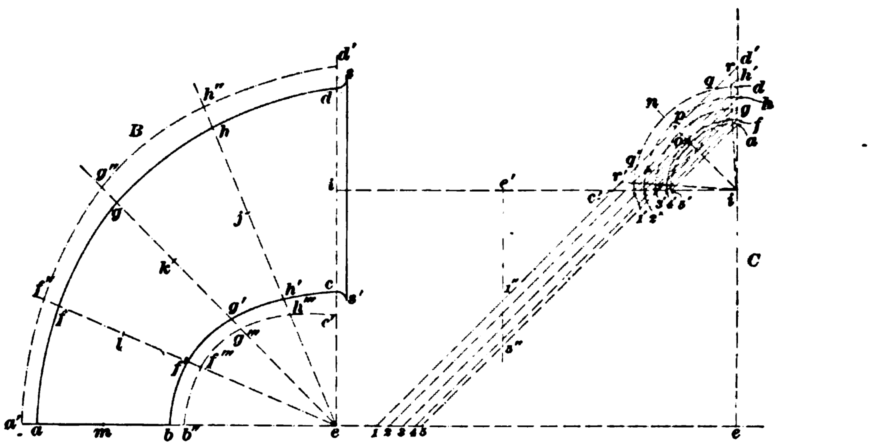


Make *1''-1'''*, *A*, = *f-1*, *B*; and with *1'''-1*, *A*, as radius and with *f*, *C*, as center describe the arc *1*. Make *e-1*, *C*, = *e-1*, *A*. The points *2*, *3*, etc., *C*, are found in a similar manner. Draw lines from all these points to *f*. Make *1'-1''''*, *A*, = *f-1'*, *B*, and make *f-1'*, poi *2'*, *3* *a g*, as c and Dra req Au Fig

(2

alt Th pla

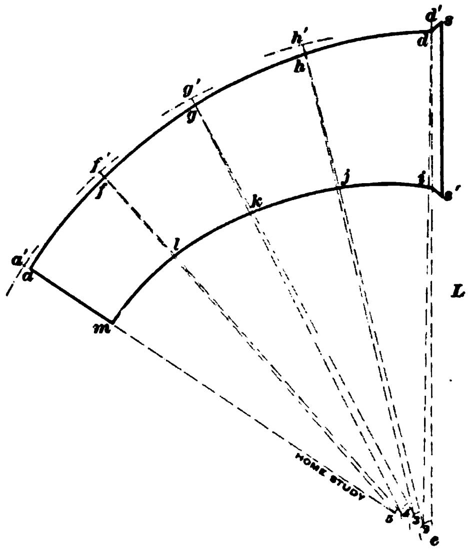
caused by the changing magnetism of the core. When the ends of the heavy wire d are brought together, a very strong current will flow, being *induced* by the action of the changing current in c. If a nail is introduced into the circuit, the heavy current will melt it, as its resistance is much greater than that of the copper wire. A transformer of this design is used in electric welding. You can make a small one by winding on a 1-inch core of soft iron wire a coil of No. 16 cotton-covered wire; let the length be about 4 inches, and put on about 500 turns. The secondary may be one or two turns of heavy copper wire, insulated from the core, and provided with clamps. (*b*) The oxygen in the air which the tumbler contains is consumed, and the pressure of the external atmosphere forces water into the tumbler to occupy the space previously occupied by the oxygen. (*c*) A cube of iron of the dimensions given would not be attracted at the distance named, with the hoisting magnet in position. (*d*) It will have no area; the spheres will touch one another at a point only.



* * *

(336) I send herewith a sketch showing dimensions of a ventilator for a steamboat. I do not understand how to lay it out. Can you show me proper method? E. Q., Lorain, O.

ANS.—It is best to make such a ventilator top of sheet copper. It can be made in halves with lengthwise seams, but it is generally easier to make it in four parts with lengthwise seams. The seams may either be cramped and brazed, or only riveted. The patterns for four such parts are obtained by the following construction: Draw the side elevation $abcd$, B, of the size and shape wanted. Extend ab and dc to meet in e. Divide the curve ad into a convenient number of parts in f, g, h or more; making these parts either equal, or those near a a little smaller than those near d. Draw fe, ge, etc. intersecting the curve bc in f', g', etc. Bisect cd in i, $h'h$ in j, $g'g$ in k, etc. Draw 1-e and ed', C, perpendicular to each other. Make ei, C, $= ei$, B, and draw ie', C, perpendicular to ei, C. With a radius $= id$, B, and with center i, C, describe the quadrant d-$1'$; with a radius $= jh$, B, and with the same center i, C, describe the quadrants h-$2'$, etc. to a-$5'$. Draw d-$1'$, C, and bisect it by the perpendicular ion, intersecting the quadrant d-$1'$ in n. Bisect on in p, and draw 1-p parallel to $1'$-d, intersecting the quadrant d-$1'$ in q and q'. Make qr and $q'r'$, C, each equal to qd, and draw ri and $r'i$. Draw h-$2'$, C, bisect its distance from the quadrant h-$2'$ on the line in, and draw a parallel to d'-1 through the middle just found, intersecting e-1 in 2, and ir and ir' as shown. Do the same for each one of the quadrants to get the other intersections 3, 4, etc. on e-1, etc. Make ed', B, $= ed'$, C; eh'', B, $= eh'$, C, etc. Draw ed' where convenient for the development L, and make ed', L, $= 1$-d', C. With a radius equal to 1-2, C, and with center e, L, describe the arc 2. Make d'-2, L, $= d'$-2, C. With a radius $= 2$-h', C, and with center 2, L, describe the arc h'. Make $d'h'$, L, $= d'h''$, B. Proceed in a similar manner to locate the points 3, 4, 5, and g', f', a', L. Make $d'd$, L, $= d'r$, C,



and di, L, $= rr'$, C; and locate the remaining points h, g, etc., and j, k, etc. in a similar manner. The flare ds, B, is added by making ds, and is', L, $= ds$, B; and ss', L, = the length of one quarter of a circle whose diameter is ss', B. By drawing the curves and lines through all these points as shown, we obtain the layout L for the upper front quarter of the ventilator. The amount of lap must be added where wanted. The layout for the throat or under part is found in a similar manner by making ie', C, $= ie$, B, and drawing e'-$5''$ perpendicular to $e'i$. The intersections $1''$ to $5''$ are then used in place of 1-5. The points c', h''', etc., B, are found by making what will be ec', L, $= ec'$, B, etc.

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CONE PULLEYS AND BACK GEARING.

Carl G. Barth.

Proper Relation Between the Back Gearing and the Cone Pulley on Machine Tools—Practical Application of the Theory of Continued Fractions.

OF THE many machine tools with which a modern workshop is equipped, by far the greater number belong to the class in which a *spindle* rotates either the work or the cutting tool, means being provided for the regulation of the rotative speed of that spindle, to suit the various sizes and kinds of work that the tool is expected to do.

The oldest, and still by far the most common, method provided for this regulation of the rotative speed of the spindle is the combination of cone pulley and back gearing. Strange as it may seem, however, the greater number of such tools, manufactured even at this late day, have the cone-pulley and back-gearing arrangements so poorly proportioned as to betray a widespread lack of insight into the essential requirement of an arrangement of this kind.

Hoping, therefore, to contribute something towards a more general and better understanding of this important matter, we will, in what follows, discuss and illustrate the principles involved and the method employed in making a good arrangement of the combination alluded to.

As an example, we will determine the diameters of the largest and smallest steps on the cone pulley, and also the various driving gears, for a lathe to swing 48 inches. We will suppose that the number n of steps in the cone is to be 5, and that the cone is to be mounted directly on the main spindle of the lathe, and to be so arranged as to drive the spindle either directly or through one or the other of *two* trains of reducing gears, thus giving the spindle a series of $3\,n = 3 \times 5 = 15$ possible speeds.

Now, these speeds ought to be so arranged that there will be a constant ratio between any two consecutive ones; in other words, so that they will form a *geometrical series;* and we will suppose that it is desirable to make the ratio r of this series as nearly as possible equal to $\frac{2}{3}$.

The first five, or n, highest speeds of the spindle will thus be the same as the five speeds of the cone itself; the next five will be the same as those of the cone, reduced by the first train of gears; while the five lowest speeds will be the same as those of the cone, reduced by the second train. The sixth highest speed must thus be the same as the highest, divided by the reduction ratio R_1 (a number greater than unity) of the first train, and the eleventh highest speed must likewise be the same as the highest, divided by the reduction ratio R_2 of the second train.

But the condition is that the second highest speed shall be equal to the highest, multiplied by $\frac{2}{3}$; that the third highest shall be equal to the second highest, multiplied, also, by $\frac{2}{3}$; the fourth highest shall be equal to the third highest, multiplied, likewise, by $\frac{2}{3}$; and so on. It thus follows that the third highest speed must be equal to the highest, multiplied by $\frac{2}{3} \times \frac{2}{3} = (\frac{2}{3})^2 = r^2$; that the fourth highest must be equal to the highest, multiplied by $(\frac{2}{3})^2 \times \frac{2}{3} = (\frac{2}{3})^3 = r^3$, and so on.

The sixth highest speed, or the highest obtainable through the first train of gears, will thus be equal to the highest speed multipled by

$$\left(\frac{2}{3}\right)^{6-1} = \left(\frac{2}{3}\right)^5 = r^n;$$

in the same manner, the eleventh highest

speed, or the highest obtainable through the second train, will be equal to the highest multiplied by

$$\left(\frac{2}{3}\right)^{11-1} = \left(\frac{2}{3}\right)^{10} = r^{2n}.$$

The reduction ratio of the first train must thus be

$$\frac{1}{(\frac{2}{3})^5} = \left(\frac{3}{2}\right)^5,$$

and the reduction ratio of the second train must be

$$\frac{1}{(\frac{2}{3})^{10}} = \left(\frac{3}{2}\right)^{10},$$

or equal to the *square* of the former ratio.

As general formulas we write this:

$$R_1 = \frac{1}{r^n}, \text{ and } R_2 = \frac{1}{r^{2n}} = R_1^2.$$

For this reason, the neatest and simplest way is to make the total reduction of the first train between the cone pulley and the

$$\frac{B}{A} = \frac{F}{E} = R_1; \quad \frac{C}{G} = 1.$$

First Train—*A, B, C, G.*
Second Train—*A, B, E, F.*

back shaft only, and to gear back to the spindle by a pair of equal wheels; and then to make the additional reduction for the second train—that is, the reduction between the back shaft and the face plate—just equal to the former reduction, all as shown on the accompanying figure.

Now, $(\frac{3}{2})^5 = \frac{243}{32}$; but, as neither of the pinions A and E can be made with so high a number of teeth as 32, we will have to content ourselves with an approximation to this ratio.

To obtain the best possible approximation, we resort to the theory of continued fractions (see HOME STUDY MAGAZINE, August, 1898, article entitled "Continued Fractions"), and proceed as follows:

```
32)243(7
   224
    19)32(1
       19
       13)19(1
          13
           6)13(2
             12
              1)6(6
                6
```

		7	1	1	2	6
$\frac{0}{1}$	$\frac{1}{0}$	$\frac{7}{1}$	$\frac{8}{1}$	$\frac{15}{2}$	$\frac{38}{5}$	$\frac{243}{32}$

The principal convergents of $\frac{243}{32}$ are, thus, $\frac{7}{1}$, $\frac{8}{1}$, $\frac{15}{2}$, and $\frac{38}{5}$.

We may now also find another series of convergents, intermediate between $\frac{15}{2}$ and $\frac{243}{32}$; thus,

$\frac{15}{2}$	$\frac{38}{5}$	$\frac{53}{7}$	$\frac{91}{12}$	$\frac{129}{17}$	$\frac{167}{22}$	$\frac{205}{27}$	$\frac{243}{32}$

As, in order to get the face-plate gear F as strong as possible, its driving pinion E on the back shaft must have a low number of teeth, so the ratio $\frac{91}{12}$ seems to be the most suitable approximation to the exact ratio $\frac{243}{32}$. This ratio would, however, mean a face-plate gear of 91 teeth, which is not only rather too odd a number of teeth, but, if we desired to make this gear as large as possible without cutting into the ways of the bed for clearance, would also lead to an odd and special pitch.

Trying, instead, the next approximation, $\frac{53}{7}$, we would then have to give pinion E 14 teeth (7 being too low a number and 14 the smallest multiple), and the face-plate gear 53×2, or 106 teeth. These gears could then be made of $2\frac{1}{4}$ diametral pitch, the outside diameter of the face-plate gear becoming, by the Brown & Sharpe rule—

$$\frac{106 + 2}{2\frac{1}{4}} = 48 \text{ inches},$$

or just equal to the swing of the lathe.

The center-to-center distance between the back shaft and the spindle would be

$$\frac{\frac{1}{2}(106+14)}{2\frac{1}{4}} = 26\tfrac{2}{3} \text{ inches},$$

which would then also be the diameter of each of the equal gears C and G. These might be made of 3 diametral pitch, when each would have $26\frac{2}{3} \times 3 = 80$ teeth. Pinion A would probably have to be given $7 \times 4 = 28$ teeth, when gear B would have $53 \times 4 = 212$ teeth, their diametral pitch being $4\frac{1}{2}$. It would probably be well to give them a somewhat wider face, in proportion, than the face-plate gear; this would be permissible on account of their being supported by bearings on both sides.

Perhaps, however, we would do better by adopting for our train ratio the still less exact approximation $\frac{15}{2}$. Pinion E would then have $2 \times 6 = 12$ teeth, and the face-plate gear $15 \times 6 = 90$ teeth, of $1\frac{5}{8}$-inch circular pitch. This would make the outside diameter of the face-plate gear

$$\frac{(90+2)1\frac{5}{8}}{\pi} = 47.578 \text{ inches},$$

and the center-to-center distance between the back shaft and the spindle,

$$\frac{\frac{1}{2}(90+12)1\frac{5}{8}}{\pi} = 26.38 \text{ inches},$$

which would then also become the pitch diameter of each of the equal gears C and G.

Pinion A would then have $2 \times 12 = 24$ teeth, and gear B, $15 \times 12 = 180$ teeth, of $\frac{13}{16}$ inch circular pitch. To avoid making a special cutter for the gears C and G, we would make them of 80 teeth and a circular pitch of

$$\frac{\frac{1}{2}(90+12)1\frac{5}{8}}{80} = 1.036 \text{ inches},$$

and then cut them with a standard cutter of 3 diametral pitch, which is equivalent to a circular pitch of $\frac{\pi}{3}$, or 1.047 inches; or, we might make them of 83 teeth and a circular pitch of

$$\frac{\frac{1}{2}(90+12)1\frac{5}{8}}{83} = .9985 \text{ inch},$$

cutting them with a standard cutter of 1 inch circular pitch.

Let us now see how much we would deviate from the required ratio of $\frac{2}{3}$ between any two consecutive speeds, by adopting either of the above arrangements of reducing trains. Let x = ratio we have obtained in place of $\frac{2}{3}$; then, in the first case we have

$$R_1 = \frac{1}{x^5} = \frac{53}{7}, \text{ or } x = \sqrt[5]{\frac{7}{53}} = .66706.$$

In the second case, we have

$$R_1 = \frac{1}{x^5} = \frac{15}{2}, \text{ or } x = \sqrt[5]{\frac{2}{15}} = .66833.$$

Either of these values of x is very little greater than $\frac{2}{3}$, or .6666, the difference being immaterial.

We next proceed to determine the diameter of the largest and of the smallest step on the cone pulley, assuming, as is usually the case, that the cone on the countershaft is to be the same as that on the lathe itself.

Denote these diameters, with an allowance for the thickness of the belt, by D and d, respectively, and the speed of the countershaft by N. We then get the highest speed of the cone on the lathe, which is also the highest speed of the spindle, to be $N\frac{D}{d}$, and the lowest speed of this cone, which is also the fifth (or nth) speed of the spindle, to be $N\frac{d}{D}$. The ratio of the lowest to the highest speed of the cone, or, what is the same thing, the ratio of the fifth (or nth) to the highest speed of the spindle, then becomes

$$\frac{N\frac{d}{D}}{N\frac{D}{d}} = \left(\frac{d}{D}\right)^2.$$

But this ratio must also be equal to $x^{5-1} = x^4$, or x^{n-1}, and thus we must have,

$$\left(\frac{d}{D}\right)^2 = x^4 = x^{n-1};$$

or

$$\frac{d}{D} = x^2 = x^{\frac{n-1}{2}}.$$

For the second arrangement of the reducing trains, we found, $x = \sqrt[5]{\frac{2}{15}}$, which, substituted in above, gives

$$\frac{d}{D} = \left(\sqrt[5]{\frac{2}{15}}\right)^2 = \left(\frac{2}{15}\right)^{\frac{2}{5}} = .44666.$$

Suppose we find that 36 inches will work in well for the actual diameter of the largest step, and that we make an allowance for the thickness of the belt of .2 inch; then D would be 36.2 inches, and we would get

$$d = 36.2 \times .44666 = 16.169 \text{ inches}.$$

Deducting from this the allowance for the belt, the actual diameter of the smallest step would become $16.169 - .2 = 15.969$ inches, which we would then approximate by $15\frac{31}{32}$ inches, or perhaps by 16 inches.

The relation established above we may now sum up in a set of general formulas, and also add a few more that may prove useful to those who like to work from formulas:

Let

r = ratio of any speed to its next higher;
R_1 = ratio of the first reducing train;
R_2 = ratio of the second reducing train;
n = number of steps on the cone pulley;
D = effective diameter of the largest steps on the cones;
d = effective diameter of the smallest steps on the cones;
N = speed of the counter shaft;
S_{max} = maximum speed of the main spindle;
S_{min} = minimum speed of the main spindle.

Then, we have found that

$$R_1 = \frac{1}{r^n}, \qquad (1)$$

$$R_2 = \frac{1}{r^{2n}} = R_1^2, \qquad (2)$$

$$\frac{d}{D} = r^{\frac{n-1}{2}} \qquad (3)$$

Solving (3) with respect to r gives

$$r = \left(\frac{d}{D}\right)^{\frac{2}{n-1}} \qquad (4)$$

which, substituted in (1), also gives

$$R_1 = \left(\frac{D}{d}\right)^{\frac{2n}{n-1}} \qquad (5)$$

Evidently, also,

$$S_{min} = S_{max} \times r^{3n-1}, \qquad (6)$$

$$S_{max} = N\frac{D}{d}, \qquad (7)$$

and $$S_{min} = N\frac{d}{D} \times \frac{1}{R_2} = N\frac{d}{D} \times \frac{1}{R_1^2}$$

Substituting herein the value of R_1 as given by (5) we further write,

$$S_{min} = N\frac{d}{D} \times \left(\frac{d}{D}\right)^{\frac{4n}{n-1}} = N\left(\frac{d}{D}\right)^{\frac{4n}{n-1}+1}$$

$$= N\left(\frac{d}{D}\right)^{\frac{5n-1}{n-1}},$$

or $$S_{min} = N\left(\frac{d}{D}\right)^{\frac{5n-1}{n-1}} \qquad (8)$$

For a machine with one reducing gear only, we get,

$$S_{min} = S_{max} \times r^{2n-1}, \qquad (9)$$

and $$S_{min} = N\left(\frac{d}{D}\right)^{\frac{3n-1}{n-1}} \qquad (10)$$

When the cone spindle is not at the same time the main spindle of the machine, but imparts its motion to the main spindle through a constant train of gears, as in large lathes and in all vertical boring and turning mills, the speed given by formulas (7), (8), (9), and (10) must, of course, be divided by the reduction ratio of this constant train.

As a rule, it is the minimum speed of the main spindle table, or face plate of a machine, that is first determined, by a consideration of the minimum cutting speed to be provided for, on the *full swing* of the machine, and which then forms the basis on which to subsequently determine the remaining quantities and numbers entering into the above given formulas.

ECONOMY IN MOTIVE POWER.

W. H. Booth.

DIRECT VERSUS INDIRECT ACTION—THE COMBINED DYNAMO AND STEAM ENGINE—COMPARISON OF THE CYCLE OF EVENTS IN THE STEAM ENGINE AND IN THE GAS ENGINE.

LOOKING back through experience, how easy it is to be wise after the event!

The writer is particularly impressed with the economy of direct action, but is at the same time forced to the conclusion that indirect methods present, as means to an end, problems that are often very much easier for the mechanician to solve: Let us take, as an example, the combined engine and dynamo—one of the newest combinations in the mechanical world. These two machines—engine and dynamo—when fixed upon the same shaft, must necessarily revolve at the same speed. This implies the skilful combination of a large number of different, and perhaps contradictory, elements. It involves the winding of the field magnets and of the armatures, the diameter of the armature and the size of the wire, due consideration of the insulation, through both the engine and dynamo, a delicate balance of parts and a careful adjustment of dimensions, so as to secure a maximum of economy at a fixed speed. The dynamo must not run too fast for the engine; yet, without high speed the voltage will be hard to obtain in the dynamo. Ask a dynamo-builder to build a dynamo that will give so many amperes of current at a given voltage, and to make the machine work at a maximum of efficiency;

make a similar request of a builder of engines, giving him merely the steam pressure, and the required horsepower; and each man will send you the best that he can produce. Perhaps the dynamo is designed to run at 900 revolutions per minute, and the engine at 150 revolutions, in which case direct coupling is out of the question; but it is a very simple matter to put a 12-inch pulley on the dynamo, and a 72-inch pulley on the engine, when at once the two machines are suited to each other. This is an example of indirect method that involves less trouble in design than the method of direct coupling. Possibly each machine is in itself fully as efficient as the machines of the direct-coupled arrangement; but it may be that the use of the belt has brought the efficiency below what it would have been had the machine been designed for direct connection, the loss due to belt friction being the price paid for an easier mechanical system, easier, that is, to design. In this example we have introduced but one additional element. Had the difference of speeds been very great, it might have been found inconvenient to drive direct from engine pulley to dynamo pulley, and we might have been compelled to put in a countershaft. This would have introduced at least two bearings and a second pair of pulleys, and the ultimate velocity of the dynamo pulley would have been secured without any serious differences of pulley diameters; but the loss in transmission would have been increased. Let us, however, take more complicated examples. We hear much of the thermodynamic and general efficiency of the gas engine, but this machine offers a very striking instance of the mechanical difficulties which surround attempts at securing the economies due to directness. First, let us study the cycle of operations performed in generating power from coal by means of the steam engine and boiler. Ordinarily, there are four actions at work. Coal upon the floor of the boiler room is merely an inert mass of carbon. The fireman's effort of mind and of muscle is necessary to place that coal in a position to change its form. To do this he puts it in contact with other coal in process of combustion—we need not here ask how that other coal attained the temperature of combustion. So placed, the fresh coal is heated to such a point that it will combine with oxygen when it burns, and the heat that has been stored up in it is set free. This is a chemical change. The heat set free by combustion is so directed as to influence the water in the boiler. Much of the heat disappears — becomes latent — as the water changes to steam. The formation of steam is a physical operation. The steam thus formed passes to the engine, and by its pressure on the piston causes the engine to rotate. By means of a governor upon the engine, the amount of steam consumed may be regulated so nicely that the engine will preserve a very regular and constant speed of rotation. Even if the steam pressure falls, the engine will keep its speed until such time as the admission valves are admitting the greatest possible supply. If the engine under this condition be required to perform more work, it will be unable to do so, but will inform us of the fact by revolving at a slower rate; and we may continue to add more and more load, and the engine will continue to run more and more slowly until a point is reached where the stored energy in the flywheel is unable to turn the crank past the dead centers. Even with this load, if we ask the engine to turn round, it will obey us if we give it steam at a higher pressure, and we can continue doing this—adding load and increasing the pressure of the steam—until the engine breaks down at its weakest part. If we cease adding fresh coal to the furnace of a boiler that supplies an engine with steam, the engine will still run for a long time; similarly, we may refuse water to the boiler and the engine will for a time run all the better—the steam being drier and the pressure being greater, because there is no feedwater to heat up. We begin to perceive that the *visible* motion of the engine is by no means dependent either upon the supply of fresh fuel or water, for we stop both, and motion continues. We shut off steam, and motion still continues, but only for a few revolutions, by virtue of the energy in the flywheel. Steam is necessary to maintain long continued movement. We thus see that, between the shoveling of the coal and the entry of the steam to the engine, there is an interval of time during which the steam that drives the engine may be supplied either from the store in the steam space, or from the stored heat in the mass of hot water in the boiler, for the engine will run quite a long time, even though we rake out the fire; and it will run a very long time with such fire as there is, though we add no more fuel. There are thus two reserves of energy: the partially consumed fuel, which is still capable of yielding heat to convert more water to steam, and the heat stored in the boiler and available for making steam on the slightest fall of pressure in the

steam space. These various stores of energy make the steam engine a very easy machine to run. In fact it will work when almost a mechanical wreck, and it is thus a very convenient machine, though it may be very wasteful by reason of this very convenience and ability to run to the last. Clearly, however, its whole cycle is very indirect, and of each element there is loss. The chemical conversion of the fuel is imperfect, and can with difficulty be carried on with a minimum of chemicals, the chief excess required being air, which reduces the temperature in the furnace, and renders more difficult the physical change produced by heat on water. The steam, when made, is exposed to great loss by radiation, and there are losses in the engine also. The final result is poor, a small portion only of the theoretical power being obtained. If now we turn to the gas engine, we find a very different condition of things. Like the steam engine, it will run a few revolutions by virtue of the stored energy in its flywheel. Cease to add fuel to its furnace, however, and it will not run a single revolution at the same speed, and would stop in less than a revolution but for its flywheel. There is no time interval between the shoveling of fuel and the entry of steam into the cylinder. To continue the simile of the steam engine, the furnace, the water space, and the steam space of the boiler and of the engine cylinder are all included in one vessel, which, for obvious reasons, must be the cylinder. Into this cylinder is put sufficient fuel to run the engine for at least two revolutions. This charge of fuel is ignited, burned, turned into "steam," allowed to press upon the piston and go to waste in two revolutions of the engine. All this occurs every two revolutions in gas engines that use the Otto cycle—by far the most common type now. If the engine begins to run slow, the governor alters its position and gives the signal for more fuel by causing the gas valve to open. A charge of gas and air enters the cylinder and the explosive stroke follows, when the engine runs more quickly, and if lightly loaded may make several revolutions before its speed falls so low as to cause fresh admission of gas. But when fully loaded the gas is admitted every two revolutions, and in such quantity as to turn the engine twice around before a fresh charge is admitted. There is only a small fraction of a second between the demand for fuel and its supply and combustion. There is no store of power or heat or partly burned fuel. What is the result of this? First comes economy. There is little time for loss when the chemical, physical, and mechanical actions take place simultaneously in one vessel; but as a fact the temperature of the furnace is so high that a very big loss has to be purposely introduced in the shape of a heat-conducting water-jacket around the cylinder, to keep it cool enough to work. By direct methods we have secured more than double the thermodynamic effect, but at considerable mechanical inconvenience. It is easy to stop a steam engine at such a point that it will start and run as soon as steam is turned on. A gas engine requires to be turned around so as to get a proper start; in small engines this is done by hand; in large ones some mechanical starting device is used. When loaded beyond its maximum power, that is, until its governor asks for fuel oftener than every two revolutions, the engine begins to run slow, and finally stops. It cannot make any effort to run at a slower speed. It must, therefore, be supplied with fuel promptly, and it must be loaded to very near its full load, or it will fall rapidly in its economy; yet it must not be loaded the least bit above full load, or it will stop. The gas engine is more direct, more scientific than the steam engine, but it is more delicate and much less convenient as a machine. Because it is more scientific and more economical, it possesses powerful arguments for existence. At the same time we may be sure that as yet it is in but an imperfect stage of development. These two arguments will doubtless prove great incentives to inventors to improve the gas engine with a view to its greater mechanical convenience. Any one who succeeds in securing a really genuine advance in this respect will do well either for himself or for whomsoever is fortunate enough to secure the invention.

HIGH RAILROAD SPEEDS.*

H. Rolfe.

THE VARIOUS ELEMENTS OF TRAIN RESISTANCE—TRUCKS VERSUS RIGID AXLES—VALUE OF CONTINUOUS BRAKES.

IN 1882 a French engineer, M. Laboriette, made extensive dynamometer tests at speeds of from 15 to 33 miles an hour, on a straight and level road. The curve $a\,b$, Fig. 5, shows graphically the relation between the speed in miles per hour and the resistance of the train. At any point,

$$R = 2.88 + .0044\,S^2, \quad (1)$$

where R = resistance in pounds per ton of 2,000 pounds;

S = speed in miles per hour.

For the equation that is stated above, the experimenter substituted the following one as being simpler and more concise:

$$R = .233\,S.$$

Now, the formulas put forward by D. K. Clark 40 years ago were as follows:

For the whole train, including the engine and tender,

$$R = 8 + \frac{S^2}{171}; \quad (2)$$

and for the train alone,

$$R = 6 + \frac{S^2}{240}.$$

In the above cases, the long ton of 2,240 pounds was used, and, further, grease was the lubricant. The equivalent formula for oil lubrication has been given in pocket-books as

$$R = 6 + \frac{S^2}{110},$$

but we do not advise its acceptance, for, although for low speeds it gives values of R smaller than does formula (2), yet, when the speed mounts up, R increases rapidly and exceeds the value given by (2). Instead of altering the expression containing the second power of S, it would have been more rational to give a lower constant.

Reducing the formula (2) to suit the short ton, and taking off 5 per cent. for internal friction of the engine, we have

$$R = 6.7857 + .00496\,S^2,$$

and we may write this,

$$R = 6.79 + .005\,S^2, \quad (3)$$

from which equation the curve $c\,d$ in the annexed diagram has been plotted. All the curves in the figure, with the exception of $c\,d$, were taken from "The Railroad Gazette," as were also the data of the tests.

For some years there has been considerable doubt as to the reliability of D. K. Clark's formulas. Observers have not only noticed that the performances of some engines precluded all idea of the above being true, but they have also felt certain that, owing to the many improvements made in the rolling stock, lubrication, and track, the resistance must assuredly be less than it had been in former years.

About 6 years ago, Mr. Angus Sinclair shed considerable light on the matter, taking a series of cards from an engine while running the Empire State Express, the highest speed attained being 78.9 miles per hour. The curve deduced from his experiments, as computed by "The Engineering News," is shown at $e\,f$, an allowance of 5 per cent. being made for the internal resistance of the engine. R was found to be $.24\,S + 2$, but the curve was plotted from

$$R = \tfrac{1}{4}\,S + 2, \quad (4)$$

as being more convenient to apply.

We doubt, by the way, if this 5 per cent. was sufficient allowance; however, for the sake of comparison, we have made the same allowance in plotting Clark's results.

Some valuable and extensive experiments have also been made by a European engineer named Barbier, the trains tested being both special and ordinary trains. The tests were made in all seasons, so as to get results virtually the same as those obtained in actual working. All observations were made on straight tracks of uniform grades. Thus, all question of resistance due to curves or to acceleration was eliminated. The average weight of the train, without the engine and tender, was 160 tons. The experimenter made too few observations at speeds under 36 or more than 69 miles an hour, to feel warranted in using them when constructing the formula, so that the speeds actually considered were from 36 to 69 miles an hour. The question of gravity did not give them any trouble, as they had a self-recording dynamometer, and it was thus a simple

* *Continued from August, 1898, Number.*

matter to determine the resistance on the level, without making any correction for the grades. The formula established was,

$$R = 3.2 + .077\,S + .0025\,S^2.$$

The constant 3.2 represents the practically constant resistances, such as the friction of the axles, rail friction (rolling), and flange friction. It will be seen that R increases rapidly with S, this being due to two causes: First, the action of the air on the cars; this was found to be the chief factor at high speeds, so a term of the second degree had to be introduced. Second, the effects of the side motion imparted to the cars; as the speed increases so does the side swaying, and the lateral shocks which are imparted to the wheels are responsible for some of the resistance encountered. Barbier regards this as varying with the speed, and it is thus accounted for by the term $.077\,S$. It was also found that, with the same weight hauled, the resistance fell slightly with an increase in the number of cars, and also that it was beneficial to have all the cars of the same cross-section rather than varying in this respect. The force of this argument seems pretty evident; it points out to us the waste of power (through air resistance) incurred in freight trains that are unskilfully made up, that is, with two or three box cars, then one or two flat cars, and so on. All the open spaces thus formed present the fronts of the box cars to the wind—especially if it is a side wind—and greatly retard progress. Conversely, vestibuled passenger trains will doubtless require less pulling than similar ones with open platforms.

For practical use, the above formula has been put into the following simple form:

$$R = 3.2 + 2.5\,S\left(\frac{S + 30.8}{1{,}000}\right) \qquad (5)$$

and it is from this formula that the curve $g\,h$ has been plotted.

It was found that freight trains offered rather less resistance than passenger trains. This was due to one or two causes. The journals of the latter cars are of larger diameter than the freight variety, and therefore their peripheries travel through a greater distance in a given number of revolutions. Now, *work* is made up of two factors: *force* and the *distance* through which it overcomes the resistance. Assuming the load per square inch of journal to be the same for each class of car, the total work done against friction will be greater in the passenger type. Also, the weight is more condensed in freight trains; the majority of the cars are lower, the stowage is more compact, and the surface exposed to atmospheric resistance is proportionately less.

During these experiments, some light was thrown on the relative values of rigid and bogie stock. The curve $i\,j$ shows how the resistance varied with the speed in the latter case. The train was made up of seven sleeping cars weighing 30 tons each. The formula corresponding to this particular case is

$$R = 3.2 + 2.5\,S\left(\frac{S + 6.08}{1{,}000}\right) \qquad (6)$$

The superiority of bogie stock was not noticeable at low speeds, as then the resistance was due almost wholly to the journal friction, and this was the same per ton of load, for the size of journals compared to that of the wheels was the same in both kinds of stock. The difference is seen, in the diagram, to increase as the speed increases. At 35 miles an hour the difference per ton of 2,000 pounds is 2.18 pounds, while at 70 miles per hour it is 4.33 pounds. This gain was considered due, in a great measure, to the number of cars being less, with a corresponding reduction in the number of spaces between them, and a consequent diminution in the amount of end-surface area exposed to the wind. Also, side motion was less pronounced in the bogie stock; and, without doubt, lateral swaying militates against high speed, by increasing the resistance due to flange friction, etc. Extended experiments were also carried out some years ago, in France, with rigid and bogie stock, which seemed to demonstrate that from 25 to 30 per cent. was gained by using trucks.

The side motion of cars is less in long cars than in short; it also diminishes, the larger the wheel base is as compared with the length of the car. In six-wheeled cars there is less weight at the ends, for a given total weight, than in four-wheelers. The former do not run so steadily, as regards side motion, as the latter.

The curve $k\,l$ was determined by the Baldwin people as the result of many careful tests carried out with passenger trains hauled by their engines. The resistance is seen to be very much less than was generally assumed to be the case. The results, as determined by them and here given in the form of a a curve, undoubtedly disarmed much of the former criticism which had greeted Baldwin and other American locomotive performances. However, the Vauclain compounds have shown pretty well, by now, what they can do, not merely in isolated cases, but day after day continuously, as witness the Atlantic City trains. Putting aside all question of

facts and records, the quiet and dispassionate way in which Mr. Vauclain answered his critics might have convinced them that he was perfectly sure of his ground. A man who, on the other hand, meets criticism with abuse (as only too often happens) generally has a weak case, or is saying that which he knows *is not*. His outpourings are, in fact, the cannonading employed to cover a retreat, course, there are many roads on which, perhaps, one very fast train per day is run, where at least three of the above conditions are absent; but, if there is to be any great amount of continuous fast traffic carried on with a reasonable assurance of safety, all these points must be observed.

When considering the question of maintaining schedule speeds of 60 or 70 miles an

FIG. 5.

to borrow one of Kaiser Wilhelm's metaphors.

Safety Appliances.—In order that very fast traffic may be carried on regularly and with safety, due attention must be paid to those means which tend to prevent accident. Thus, there should be an efficient block system, as well as interlocking apparatus, continuous automatic brakes, and a double track. Of hour, or even greater speeds, we must pay particular attention to the distance in which the train can stop after receiving intimation of danger. Some years ago the Pennsylvania Railroad Co. made an estimate in connection with this question, for various speeds. The engineer who conducted the tests found that trains such as he was dealing with, when running at 60 miles an hour, could be stopped

in 900 feet; when running at 80 miles an hour in 1,600 feet, at 90 miles in 2,025 feet, and at 100 miles in 2,500 feet—always assuming that the brakes work all right and the full brake power can be utilized. We see, therefore, that in good weather and with all conditions favorable, the track should at all times be clear for a distance of more than 2,000 feet for a speed of 90 miles an hour. The above engineer also points out that when the weather is foggy or the rails are slippery, or the road is on a down grade, still more clearance is necessary. It may be remarked, however, that no enginemen would be so reckless as to maintain these high speeds in a fog, and that the presence of slippery rails would in itself operate against the attainment of such high speeds. Then, again, the personal equation enters in—and pretty largely too.

The continuous brakes now used—notably the Westinghouse—have enabled schedules to be greatly accelerated, especially in stopping trains. In the old days, when there was only a brake on the tender (assisted or not by the guard's brake, according as that gentleman thought fit) steam had to be shut off about 1½ miles from a station, the particular distance varying, of course, with the speed in hand. If the weather was bad or the sand had given out, it was advisable to give oneself a larger margin. And, in foggy weather, the only thing to do was to run cautiously all the time, for the distance at which one could see the distant or home signals was materially lessened.

Nowadays, with the air brake, enginemen delay shutting off steam till the very last moment, so to speak. It is interesting to watch the suburban trains around London, fitted, as they are, with these continuous brakes. They have to stop every mile or so, and their only hope of keeping up a decent schedule is to do as they are in the habit of doing, namely, dash into the station at full speed, shut off, and whip on the brakes at once. Thus the actual period of "slowing-down" is reduced to a minimum.

The writer remembers the interest evoked by early trains in England thus fitted with continuous brakes—going back more than twenty years. People on the platform had been accustomed to seeing a train shut off in the far distance and gradually roll in, creeping into the end of the station *very* carefully—for in England a driver is fined if he overshoots a platform and has to "set back" before the passengers in the front cars can alight. But, after a while, especially when the men had "got their hands in," trains were to be seen dashing boldly up at full speed, not closing the throttle until the end of the platform was reached, and *then* the brakes would go on, and she would gradually pull up, often and again deceiving onlookers, who thought she was going to "run by" *this* time, for sure.

In England, on some lines, they are not allowed to use the air brake in running into terminal stations, lest it should give out. All the same, the drivers generally *do* use it. They test it about a couple of miles from home, and if they find it working all right, they let her go. It is very seldom indeed that it fails them, even partially. If anything serious happens beforehand, such as a coupling bursting, the brakes set themselves, as is well known.

The effect on the trainmen of the possession of this brake is beneficial. It eases the strain on them considerably. They can run at high speeds on dark nights or around curves with a degree of "feeling at ease" that they formerly did not possess. They know that, if anything is in the way, or a signal is thrown back on them suddenly, they have at their command a means of stopping quickly.

In short, as Mr. Sinclair remarked in one of his lectures not long ago, Westinghouse will have a better claim to a monument when he dies, than Napoleon ever had. Each has been responsible for hundreds of thousands of lives, but, whereas Napoleon *destroyed* them, Westinghouse is always *saving* them.

(*To be Concluded.*)

THE DISTRIBUTION OF ARTIFICIAL LIGHT.

Arthur Farnsworth.

Direct Rays of the Sun Seldom Used—Diffused Light—Variation of Intensity of Direct Illumination—Best Arrangement of Lights in a Public Hall.

ALTHOUGH the theory of the distribution of light is very simple, it is not always that lighting installations give the results expected. In certain places, the brightness of the lights may be particularly noticeable, and yet one may be unable to read with comfort unless close beside one of them. On the other hand, a room, when first entered, may appear quite poorly lighted, yet ordinary print may be read in any part of it without difficulty.

Unsatisfactory illumination is usually the result of carelessness or ignorance. Nature originally intended our eyes to be used with sunlight, and this is what we must strive to imitate. A knowledge of the principles underlying the distribution of sunlight will enable us to secure the maximum useful effect from artificial light for the least expenditure.

Direct sunlight is hardly ever used for interior illumination. Even when a beam of it enters a room, no one thinks of using it for reading or sewing by. This is not because the light is too strong, for, if necessary, our eyes could become accustomed to its mere intensity; it is because the contrasts between light and shade, black and white, polished and rough surfaces, are too great. The eye, by unconsciously adjusting the size of its pupil, adapts itself to the amount of light passing into it when looking at an object. The process takes a little time, and necessitates a certain effort. If the intensity of the light penetrating the eye is continually changing between wide limits, as when we attempt to work in direct sunlight, it is obvious that the eye will soon tire from the strain imposed upon it.

The daylight that we ordinarily make use of in our homes is said to be *diffused*, by which is meant that the individual rays come from all directions. This is accomplished by successive reflection from the innumerable small surfaces which serve as reflectors, such as the particles of dust always present in the air, the minute irregularities of the wall paper and of every surface that the rooms contain.

Perfectly diffused light would cast no shadow, and is never attained in practice. There is always some direction from which the rays come more directly, and, therefore, with greater intensity, because the process of reflection absorbs a certain amount of light. As it is usually an advantage to have a large volume of light at our command, provided it is properly diffused, we must understand the laws governing both intensity of illumination and diffusion of light if we are to imitate the light of nature.

The intensity of direct illumination is said to vary directly as the intensity of the source, and inversely as the square of the distance from that source. This means that, if we make the source twice as bright, we shall secure twice the illumination at every point; while, if we approach the source so that it is but one-half its original distance from us we shall get four times the illumination. The reason for this latter can be understood by referring to Fig. 1.

Fig. 1.

Suppose we take three pasteboard screens, and in the center of one—*A*, Fig. 1—cut a small, square hole *d*, and over it paste a piece of white tissue paper *p*. The second plate, *B*, we perforate with a small pin, as at *h*, and the third plate, *C*, we leave plain. If, now, the apparatus is arranged as shown, in a darkened room, a powerful gas jet being placed with its flat side close to the square hole, we shall get an enlarged image of the latter upon the screen *C*. If the room is sufficiently dark, and the screens large enough to prevent any light from reaching *C* except that which passes through the pin hole, the image will be quite sharp, and its length and breadth can be easily measured. If, now, we move *C*

towards B until it is just half the original distance, the image will be smaller, but brighter and more sharply defined, than before. Upon measuring, it will be found to be half as long and broad as it was before. Since the area of the rectangle equals its length multiplied by its breadth, the area of the second image will be one-quarter of the first. Now, all the light passing through the pin hole—and it must be remembered that the pin hole is the source of light as far as screen C is concerned—falls upon the screen C within the illuminated square, no matter where C is placed. There is just as much light falling upon the small image as upon the large one, and, as the area of the former is but one-fourth of the latter, the intensity of illumination, or the amount of light falling upon each unit of surface, is four times as great. That the law is true can also be proved by geometry.

As an example of an application of this law, let us consider some of the ways of lighting, say, a lecture hall where no special illumination is needed in any one place, but a general distribution is desired, so that persons in the various parts of it can see to read with equal facility. Suppose we are allowed for this purpose a maximum of twelve 16-candlepower incandescent lamps, and are required to place them to the greatest possible advantage for securing the results mentioned. If the height of the ceiling is 15 feet, we will be required to have a good distribution 12 feet below this, or 3 feet from the floor—the height at which reading matter is ordinarily held.

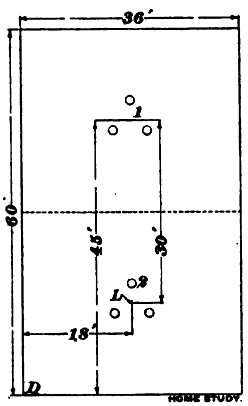


FIG. 2.

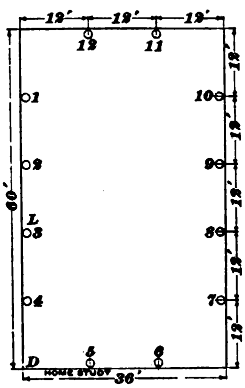


FIG. 3.

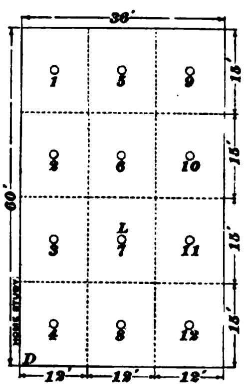


FIG. 4.

First, suppose we divide the room lengthwise into two equal parts, and place a cluster of three 32-candlepower lamps in the center of each, as in Fig. 2. The darkest points will evidently be in the corners, as at D. The distance from D (which is 12 feet below the level of the lights) to the nearest cluster *2* is

$$\sqrt{12^2 + 18^2 + 15^2} = \sqrt{693} = 26.4 \text{ feet,}$$

and to cluster *1* is

$$\sqrt{12^2 + 18^2 + 45^2} = \sqrt{2{,}493} = 49.9 \text{ feet.}$$

The lightest part of the room is directly beneath the center of one cluster, as at L, the distance to it being, therefore, 12 feet. From this point to the other cluster the distance is

$$\sqrt{12^2 + 30^2} = \sqrt{1{,}044} = 32.3 \text{ feet.}$$

If we take as our unit of intensity of illumination, in this and the succeeding solutions, the intensity due to one 16-candlepower lamp at the distance of 1 foot, then, remembering that the intensity varies directly as the intensity of the source, and inversely as the square of its distance, we have, for the intensity of illumination at D, the following:

Intensity due to cluster *1* $= \frac{6}{2493} = .00241$ unit.
Intensity due to cluster *2* $= \frac{6}{693} = .00866$ unit.
Total intensity due to clusters *1* and *2* $= .01107$ unit.

The intensity of illumination at L is given below:

Intensity due to cluster *1* $= \frac{6}{1044} = .00575$ unit.
Intensity due to cluster *2* $= \frac{6}{144} = .04170$ unit.
Total intensity due to clusters *1* and *2* $= .04745$ unit.

The intensity at D will, therefore, be $\frac{.0111}{.0474} = .234$ times that at L, or the extreme variation with this arrangement will be 76.6 per cent.

Now place the light as shown in Fig. 3. The lightest part will be directly beneath either lamp *2*, *3*, *8*, or *9*, as at L, and the darkest at D, in the corner, as before. The distances from these points to the twelve lights, and the illumination due to each, is given in the following tables. The points L and D are assumed to be 12 feet below the level of the lights.

With this second arrangement of the lights, therefore, the intensity of illumination at D will be $\frac{.0131}{.0208} = .630$ times that of L, or

the extreme variation will be 37 per cent. Now try the arrangement shown in Fig. 4, in which the room is divided into twelve equal squares, with a single light in the center of each. Proceeding in the same manner as in the other solutions, we find the

TABLE OF DISTANCES IN FIG. 3.

Distance From L to Lamp.		Distance From D to Lamp.	
No. of Lamp.	Distance in Feet.	No. of Lamp.	Distance in Feet.
1	$\sqrt{12^2+24^2} = \sqrt{720}$	1	$\sqrt{02^2+48^2} = \sqrt{2{,}448}$
2	$\sqrt{12^2+12^2} = \sqrt{288}$	2	$\sqrt{12^2+36^2} = \sqrt{1{,}440}$
3	$12 = \sqrt{144}$	3	$\sqrt{12^2+24^2} = \sqrt{720}$
4	$\sqrt{12^2+12^2} = \sqrt{288}$	4	$\sqrt{12^2+12^2} = \sqrt{288}$
5	$\sqrt{12^2+24^2+12^2} = \sqrt{864}$	5	$\sqrt{12^2+12^2} = \sqrt{288}$
6	$\sqrt{12^2+24^2+24^2} = \sqrt{1{,}296}$	6	$\sqrt{12^2+24^2} = \sqrt{720}$
7	$\sqrt{12^2+12^2+36^2} = \sqrt{1{,}584}$	7	$\sqrt{12^2+36^2+12^2} = \sqrt{1{,}584}$
8	$\sqrt{12^2+36^2} = \sqrt{1{,}440}$	8	$\sqrt{12^2+36^2+24^2} = \sqrt{2{,}016}$
9	$\sqrt{12^2+12^2+36^2} = \sqrt{1{,}584}$	9	$\sqrt{12^2+36^2+36^2} = \sqrt{2{,}736}$
10	$\sqrt{12^2+24^2+36^2} = \sqrt{2{,}016}$	10	$\sqrt{12^2+36^2+48^2} = \sqrt{3{,}744}$
11	$\sqrt{12^2+36^2+24^2} = \sqrt{2{,}016}$	11	$\sqrt{12^2+60^2+24^2} = \sqrt{4{,}320}$
12	$\sqrt{12^2+36^2+12^2} = \sqrt{1{,}584}$	12	$\sqrt{12^2+60^2+12^2} = \sqrt{3{,}888}$

TABLE OF ILLUMINATIONS IN FIG. 3.

Illumination at L Due to Lamp.		Illumination at D Due to Lamp.	
No. of Lamp.	Illumination in Units.	No. of Lamp.	Illumination in Units.
1	$\frac{1}{720} = .00139$	1	$\frac{1}{2{,}448} = .00041$
2	$\frac{1}{288} = .00347$	2	$\frac{1}{1{,}440} = .00069$
3	$\frac{1}{144} = .00695$	3	$\frac{1}{720} = .00139$
4	$\frac{1}{288} = .00347$	4	$\frac{1}{288} = .00347$
5	$\frac{1}{864} = .00116$	5	$\frac{1}{288} = .00347$
6	$\frac{1}{1{,}296} = .00077$	6	$\frac{1}{720} = .00139$
7	$\frac{1}{1{,}584} = .00063$	7	$\frac{1}{1{,}584} = .00063$
8	$\frac{1}{1{,}440} = .00069$	8	$\frac{1}{2{,}016} = .00050$
9	$\frac{1}{1{,}584} = .00063$	9	$\frac{1}{2{,}736} = .00037$
10	$\frac{1}{2{,}016} = .00050$	10	$\frac{1}{3{,}744} = .00027$
11	$\frac{1}{2{,}016} = .00050$	11	$\frac{1}{4{,}320} = .00023$
12	$\frac{1}{1{,}584} = .00063$	12	$\frac{1}{3{,}888} = .00026$
	Total, .02079		Total, .01308

illumination at D to be $\frac{.0127}{.0298} = .427$ of that at at L, or the extreme variation is 57.3 per cent.

It is not claimed that the arrangement of Fig. 3 is the best possible, and it is doubtful if we should concern ourselves with how much light is received in the extreme corners, because they will, perhaps, never be used. The solutions, however, indicate the general method of procedure and the great importance of an analysis of this kind in every installation of any size. They also show that, in general, it is better to subdivide the source instead of bunching the lights together; this subdivision should not, however, be carried too far, owing to the increased expense of installation. It is for this reason that, in England, the standard lamp is the 8-candlepower, instead of the 16-candlepower, as with us.

A subdivision of the source will also have a beneficial effect, similar to that of diffused light, in that the individual rays are coming from several directions. This condition assists the subsequent diffusion. The same principle is made use of when an arc lamp is shaded by a ground-glass globe, which changes the effective size of the source from a point to that of a good-sized sphere.

The principle of diffusion is very simple, and needs no special explanation. Dull surfaces are much more effective in diffusing light than are smooth or polished surfaces, as there is a greater multiplicity of the minute reflecting areas. Light-colorde surfaces are also better than dark ones, as the latter absorb all the light except that

which is reflected as the color of the object.

In general, when laying out a lighting installation, success depends upon good judgment in applying the principles we have been discussing, to suit the individual conditions. We must recognize how much, and where, light is wanted, and select a proper size and kind of source. In short, by mastering the principles involved, we can obtain the greatest possible benefit from the allowable initial expense of installation.

AIDS TO RAPID CALCULATING.

George McC. Robson, M. A.

THE AREA OF A CIRCLE—CONTRACTED MULTIPLICATION—CONTRACTED DIVISION.

THE ability to calculate rapidly and accurately is of the very greatest importance.

It is of more importance for young people to acquire facility in the ordinary operations of arithmetic than to learn to solve very difficult problems. If a young man, on entering an office, does not know how to make some calculation required in his work, one of the seniors in the office will gladly show him. If, however, the young man knows how everything ought to be done, but makes blunders in his work, or is so slow as to delay the work of the whole office, he will receive little help or sympathy.

Any person can become fairly expert in the simple arithmetical operations by perseverance; and no person should attempt to employ contracted methods till he can perform the simple operations with unerring accuracy. In using contractions, it is necessary to examine the methods carefully and intelligently, for many rules for contracting arithmetical operations are pitfalls for the unwary, and give grossly inaccurate results.

A quick eye for combinations of numbers will detect many easy methods. Thus, let it be required to find the area of a circle with a diameter of 147 inches. The area $= 147^2 \times .7854$, or $21{,}609 \times .7854$. The scheme shown at the right suggests the following easy way of multiplying by .7854:

.7
.07
.014
.0014
.7854

21609
.7

15126.3 = square of diameter × .7.
1512.63 = 1st line moved one place to right.
302.526 = 1st line × 2, two places to right.
30.2526 = 3d line moved one place to right.

16971.7086

A great saving of time and labor is effected by using the contracted method for the multiplication of large numbers. For example, find the product of 1,048.45478 and 47.117350 correct to four decimal places. The complete operations, both contracted and uncontracted, are here exhibited, the explanation being given below.

(*Contracted.*)	(*Uncontracted.*)
1048.45478	1048.45478
47.117305	47.117305
41938.1912	41938.1912
7339.1835	7339.18346
104.8455	104.845478
10.4845	10.4845478
7.3392	7.33918346
.3145	.3145364340
. 52	.00524228390
49400.3636	49400.36364797790

In the uncontracted multiplication, the only departure from the usual rule is that the partial products are written in reverse order. The multiplication, instead of beginning with the figure at the right of the multiplier begins with the figure at the left. Thus, $1{,}048.45478 \times 40 = 41{,}938.1912$; this gives the first partial product, and fixes the position of the decimal point. The second partial product, $1{,}048.45478 \times 7 = 7{,}339.18346$, is written one place farther to the right than the first one. Each of the remaining partial products is written one place farther to the right than the preceding one. Adding the partial products, the complete product is 49,400.36364797790.

In the contracted form, the multiplication begins with $1{,}048.45478 \times 40 = 41{,}938.1912$, as in the uncontracted form. Before taking the second partial product, the last figure, 8, of the multiplicand is stricken off; the last figure, 8, is mentally multiplied by the second figure, 7, of the multiplier, to determine the amount to be carried. Thus, $7 \times 8 = 56$; this is nearer to 60 than 50;

hence, we have 6 to carry, and the second partial product is $10,484,547 \times 7 + 6 = 73,391,835$. Write this partial product with its right-hand figure directly under the right-hand figure of the first partial product. Strike off the second figure, 7, from the multiplicand before multiplying by 1, the third figure of the multiplier, and take the product of 7 and 1 mentally, to find how much to carry. Since 7 is nearer to 10 than to 0, there is 1 to carry; thus, the third partial product is $1,048,454 \times 1 + 1 = 1,048,455$. Place this partial product with its right-hand figure directly under the right-hand figures of the first two partial products. The remaining partial products are similarly calculated, and the complete product is found to be 49,400.3636. The answer found by the contracted method agrees with that found by the uncontracted method to four decimal places, and the contraction saves the labor of finding seven additional figures in the product, which are of no use when found. If care is exercised to carry the correct amount to the first figure of each partial product, the result should always be accurate to within one unit in the last place.

Contracted division is easier than contracted multiplication, and effects at least an equal saving of labor. The rule given in many textbooks on arithmetic is inaccurate and therefore worthless. For the sake of clearness two rules are here given, for distinct cases.

I. When the first digit at the left of the divisor is less than the first digit at the left of the dividend:

Rule.—1. Multiply or divide both dividend and divisor by such a power of 10 as will make the number of figures in the integral part of the dividend equal to the number of figures required in the quotient, and strike off all the other figures from the dividend.

2. Annex as many ciphers to, or strike off as many figures from, the right of the divisor as may be necessary to make the number of figures in the divisor equal to the number of figures required in the quotient.

3. Find the first figure of the quotient in the usual way; before seeking the second figure, strike off one figure from the right of the divisor; before seeking the third figure, strike off the second figure from the right of the divisor; and so on.

4. Place the decimal point in the quotient when the first figure to the left of the decimal point in the divisor is stricken off.

For example, divide 79,658.78 by 29.76358. Multiplying dividend and divisor by 100, we get

```
2976.358)7965878(2676.384
         5952716
         -------
         2013162
         1785815
         -------
          227347
          208345
          ------
           19002
           17858
           -----
            1144
             893
            ----
             251
             238
             ---
              13
              12
              --
               1
```

The first figure of the quotient is 2; after subtracting twice the divisor from the dividend, strike off the 8 from the right of the divisor. The second figure of the quotient is 6; multiply 8 by 6 mentally to determine how much to carry; thus, $8 \times 6 = 48$, which is nearly 50; hence, there are 5 to carry. Then $297,635 \times 6 + 5 = 1,785,810 + 5 = 1,785,815$, which is to be subtracted from the last remainder. Strike off 5 from the divisor before seeking the third figure of the quotient. Strike off 3 before seeking the fourth figure. Before seeking the fifth figure, the sixth must be stricken off and the decimal point placed in the quotient.

II. When the first figure at the left of the divisor is greater than the first figure at the left of the dividend:

Rule.—1. Multiply or divide both dividend and divisor by such a power of 10 as will make the number of figures in the integral part of the dividend one more than the number of figures required in the quotient, and strike off all the other figures from the dividend.

2. Annex as many ciphers to, or strike off as many figures from, the right of the divisor as may be necessary to make the number of figures in the divisor one more than the number of figures required in the quotient.

Rules 3 and 4 are same as given under Case I.

In counting the number of figures in a quotient for the purpose of the rule, zeros at the left are not counted; thus, the number of figures in .00037 is 2, though there are five decimal places.

For example, divide 439.7258254 by 987,-248.3636 to eleven decimal places. Clearly, the quotient is less than $\frac{900}{900,000}$, or .0001. Hence, the required quotient will have at least four ciphers after the decimal point. So that, for the purpose of the rule, we only count

seven figures in the quotient. Multiplying both dividend and divisor by 100,000 we get

$$98724836360 \mid 43972582.54$$

Retaining eight figures of both dividend

$$\begin{array}{lrl}
98724836\cancel{3}\cancel{6}\cancel{0} & 43972582.\cancel{5}\cancel{4} & \mid .00004454055 - \\
9\cancel{8}\cancel{7}\cancel{2}\cancel{4}\cancel{8}\cancel{3}\cancel{6} & \underline{39489934} & \\
 & 4482648 & \\
 & \underline{3948993} & \\
 & 533655 & \\
 & \underline{493624} & \\
 & 40031 & \\
 & \underline{39490} & \\
 & 541 & \\
 & \underline{494} & \\
 & 47 & \\
 & \underline{49} & \\
\end{array}$$

and divisor, the dividend is 43,972,582 and the divisor is 98,724,836; but here three figures have already been stricken from the integral part of the divisor; therefore, the decimal point is placed in the quotient followed by three zeros. Since 98,724,836 is not contained in 43,972,582, the next figure of the quotient is also zero. Then 6 is stricken from the divisor, and so on. The answer is correct to eleven decimal places.

At first sight, the short method of division looks more formidable than the contracted method of multiplication, but it will be found that less care is required to obtain correct results in division than in multiplication. Few persons realize the enormous saving of labor that may be effected by these methods.

A QUESTION IN LAND SURVEYING.

Benj. F. La Rue.

The Subdivision of Section 6.

A SUBSCRIBER for Home Study Magazine has sent in the following question:

"In the Instructions which the General Land Office furnishes to surveyors, it says: 'Where retracements of lines have to be made for the purpose of either testing the relocation of a missing corner, or by direct measurement between known corners intersecting at the point sought to be replaced, it will almost invariably happen that a difference of measurement is developed between the original measurement as stated in the field notes and the new measurement made for the purpose of reestablishment or proof. When these differences occur, the surveyor must, in all cases, reestablish or prove his corners at intervals *proportionate to those given in the field notes of the original survey.* From this rule there can be no departure, since it is the basis upon which the whole operation depends for accuracy and truth.'

"I would like you to illustrate this entire matter, and give full instructions as to the manner of solving the proportional problems arising in subdivision of sections upon the north and west of townships, as well as section 6."

This being a matter of general interest to surveyors, it is here made the subject of a brief article.

In order to clearly understand the matter, it will be well to notice, first, the manner in which the townships were originally subdivided. The township and range lines having been run, the corners established on these lines become also the corners for the sections adjoining them on the north and west, that is, for the south and east tiers of sections in each township, but *not* for the north and west tiers of sections, if surveyed previous to 1846. In the government surveys, the north and south boundaries of townships are designated as *township lines*, and the east and west boundaries are called *range lines*. Thus, the corners established on the south line of the township, Fig. 1, become corners for the adjoining sections *31* to *36*, inclusive, of this township, but *not* for sections *1* to *6* of the township adjoining on the south, if surveyed previous to 1846; and the corners established on the east line of the township become corners for the adjoining sections *1*, *12*, *13*, *24*, *25*, and *36*, but *not* for sections *6*, *7*, *18*, *19*, *30*, and *31* of the township adjoining on the east, if surveyed previous to 1846. Likewise, the corners established on the north boundary of this township belong to sections *31* to *36*, inclusive, of the township adjoining on the north, but *not* to sections *1* to *6* of this township, if surveyed previous to 1846; and the corners established on the west line of the township belong to sections *1*, *12*, *13*, *24*, *25*, and *36*, of the township adjoining on the west, but *not* to sections *6*, *7*, *18*, *19*, *30*, and *31* of this township, if surveyed previous to 1846. In the later surveys, how-

ever, the section and quarter-section corners on the township and range lines are common to the adjoining townships *on both sides* of those lines.

The section lines were run in the order of the small figures written at the corners of the sections, in Fig. 1. Thus, beginning at *1*, on the south boundary of the township, the line *1-2* is run north, and the corner of sections *25*, *26*, *35*, and *36* established; and from this corner the line *2-3* is run east as a *random* line to the corner at *3*, on the east boundary, or range line, setting *temporary* quarter-post at 40 chains. If the random line does

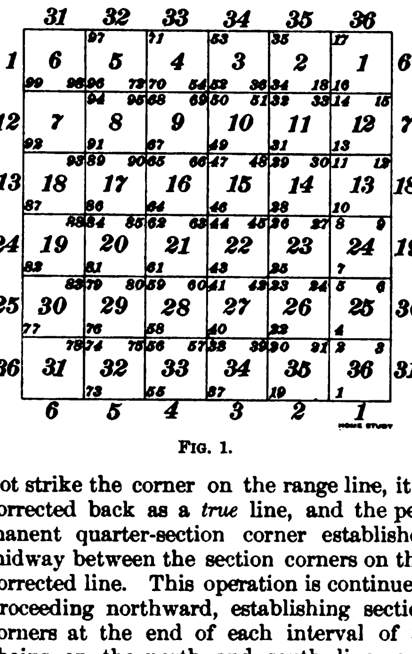


FIG. 1.

not strike the corner on the range line, it is corrected back as a *true* line, and the permanent quarter-section corner established midway between the section corners on this corrected line. This operation is continued, proceeding northward, establishing section corners at the end of each interval of 80 chains on the north and south line, and quarter-sections midway between the section corners, until the line *15-16* is established between sections *12* and *1*.

In running the line *16-17* north between sections *1* and *2*, in the surveys previous to 1846, the quarter-section corner is established at 40 chains from the corner of sections *1*, *2*, *11*, and *12*, throwing the excess or deficiency in the remaining portion of the line; and the section corner is established at the intersection of this line with the township line, its distance from the section corner established on the township line being measured and noted. In the later surveys, this line is run north as a *random* line to an intersection with the township line, and if it does not intersect at the corner, it is corrected back as a true line intersecting at the corner; a temporary quarter-post is set at 40 chains from the corner of sections *1*, *2*, *11*, and *12* on the random line, and the permanent corner established in the corresponding position on the corrected, or true line. When the north boundary of the township is a base, or standard, line, however, the line between sections *1* and *2* is run north as a *true* line, and the closing corner established at the point of intersection with the base or standard line, the distance from the closing corner to the nearest section or quarter-section corner on the base, or standard, line, being measured and noted as a connecting line.

This operation is repeated for each tier of sections, proceeding toward the west. The line run north between the last two tiers of sections starts at *73*, the corner for sections *31* and *32*. From this corner it is run north 80 chains to *74*, the corner for sections *29*, *30*, *31*, and *32*, from which corner it is run east, closed on *75*, the corner for sections *28*, *29*, *32*, and *33*, and corrected back, then run west, and, in surveys later than 1846, closed on 77, the corner for sections *30* and *31* on the range line, and corrected back, in precisely the same manner that the line was run north between sections *1* and *2*, and closed on the township line. The quarter-section corner is established on the corrected line at a distance of 40 chains west of the corner for sections *29*, *30*, *31*, and *32*, throwing the excess or deficiency wholly in that part of the line between the quarter-section corner and the corner on the township boundary, the same as for the north tier of sections. This process is continued northward until the lines between sections *5* and *6*, and sections *6* and *7*, are established, completing the survey of the township.

Understanding, now, the manner in which the townships were subdivided, it will not be difficult to interpret the language of the Instructions of the General Land Office in regard to retracements of lines for the purpose of testing the relocation of a missing corner. It must be distinctly understood that in all cases the original corners, when they can be found, must stand as the true corners they were intended to represent, and cannot under any circumstances be changed. Not only is this principle rigidly upheld by the courts, but they also hold that proper evidence of the positions of such corners will hold against any subsequent surveys that can be made. It is the surveyor's duty to find out, not where a corner or line should have been, but *where it actually was*. If all

local evidences of the position of a corner have become obliterated, it must then be relocated in as nearly its original position as possible by measurements of the lines as originally surveyed, from the nearest known corners; or it may be necessary to employ such measurements for the purpose of identifying a corner whose position may be doubtful. It is to such measurements or "retracements" of the originally surveyed lines that the above paragraph, quoted from the Instructions of the General Land Office, relates.

In making these measurements, it will almost invariably be found that they differ from the original measurements given in the field notes, in which case they must be made proportionate to the original measurements. Except in the north and west tiers of sections, a quarter-section corner would be relocated on the section line *midway* between the adjacent section corners, whether the distance between the section corners was found to be just 80 chains or any other distance, as 83 chains and 20 links. In the latter case, it would be at a distance of $\frac{83.20}{2} = 41$ chains and 60 links from each adjacent section corner.

In the north tier of sections, the quarter-section corners on the north-and-south section lines are at a distance of 40 chains of the original measure* from the section corners on the south lines of those sections, as stated above, so that the east-and-west quarter-section line through this tier of sections must be of a uniform distance of 40 chains, original measure, from the section line forming the south boundary of those sections, throwing all excess or deficiency in the quarter-sections adjacent to the north boundary of the township. Under the prescribed regulations, these fractional quarter-sections adjoining the north line of the township are to be divided into half-quarters by lines running east and west parallel with, and 20 chains of the original measure distant from, the quarter-section line, thus throwing, finally, the fractional excess or deficiency of each section in this tier, due to the measurements of the north and south lines, into the half quarter-sections adjacent to the north township line.

In precisely the same manner, the excess or deficiency in the west tier of sections, due to measurements of the east and west lines, is thrown wholly into the half quarter-sections adjoining the west line of the township. These half quarter-sections adjacent to the north and west boundary lines of the township, into which is thrown the entire excess or deficiency, are known as fractional half quarter-sections. Section *6*, situated in the northwest corner of the township, contains fractional half quarter-sections adjoining both the north and the west lines of the township, rendering its subdivision somewhat complicated. Where the original corners of this section are lost, their relocation is often a matter of great difficulty.

Fig. 2 is a plot of section *6*, represented as taken from the field notes of the original survey, and showing the manner of subdividing it into half quarter-sections. It will be noticed that the northeast and northwest quarter-sections are subdivided by the east-and-west eighth line $c\,h$, parallel to, and at a distance of 20 chains from, the east-and-west quarter-section line $D\,H$, corresponding to the manner of subdividing the quarter-sections in the north tier of sections, but that the southwest quarter-section is subdivided by the north-and-south eighth line $m\,f$, parallel to, and a distance of 20 chains from, the north-and-south quarter-section line $B\,F$, corresponding to the manner of subdividing the west tier of sections. The southeast quarter-section is subdivided in the regular manner by the north-and-south eighth line $n\,e$, midway between the section and quarter-section lines. In order to illustrate the matter of proportionate distances in the subdivision of sections, we will now notice the manner in which the positions of the lines $n\,e$, $m\,f$, and $c\,h$, should be located by the surveyor.

It will be assumed that the positions of the government corners at A, C, D, E, F, and G are known. If the original survey was made previous to 1846, and the section lines $E\,C$ and $E\,G$ did not close on the corners on the township line at C and G, the closing corners, or corners for this township, will, of course, not be identical with the corresponding corners on the township lines, and consequently the quarter-section corners set on the township lines at B and H will not be the quarter-section corners for this section; in this case the positions of the quarter-section corners for this section at B and H must be located by the surveyor as the first step toward the subdivision of the section. The quarter-section corner for this section at B should be located on the township line at a

* By original measure is meant the measure actually laid down on the ground by the deputy surveyors who made the original survey, as recorded in the field notes.

distance of 40 chains, of the original measure, from the intersection of the section line $E\,C$ with the township line, that is, from the closing corner at C. The distance, by the original measure, of the closing corner at C from the township corner at A, as given on the plot, is $40.00 + 42.40 = 82.40$ chains, and, consequently, the quarter-section corner at B, for this section, should be located at a distance from the closing corner at C equal to $\frac{40.00}{82.40}$ of the distance from the latter corner to the township corner at A, as determined by measurement. For instance, suppose that the surveyor finds that this distance actually measures 83.43 chains, instead of 82.40, as given by the field notes. We then have the proportion $82.40 : 40.00 :: 83.43 : B\,C$, from which the required distance

$$B\,C = \frac{40.00 \times 83.43}{82.40} = 40.50 \text{ chains.}$$

Likewise, the quarter-section corner at H for this section is located on the west line of the township at a distance from the closing corner at G equal to $\frac{40.00}{81.50}$ of the distance, as determined by actual measurement, from this closing corner to the township corner at A. If, however, the section lines $E\,C$ and $E\,G$ close upon the section corners established on the township lines at C and G, then the quarter-section corners established at B and H on those lines will be the quarter-section corners for this section also.

The quarter-section corners at B, D, F, and H being now known, the corner at the center of the section o is located at the intersection of the north-and-south and the east-and-west quarter-section lines, as run straight from F to B, and from D to H. The corner at c is located on the section line $E\,C$ at a distance of 20 chains of the original measure from D, that is, at a distance equal to $\frac{20.00}{40.80}$ of the distance from D to C, as actually measured. Thus, if the distance $D\,C$ is found to measure 41 chains and ½ link, the distance $D\,c$ will be given by the proportion,

$$40.80 : 20.00 :: 41.005 : D\,c,$$

from which,

$$D\,c = \frac{20.00 \times 41.005}{40.80} = 20.10 \text{ chains, closely.}$$

Likewise, the position of the corner at h is located on the west line of the township at a distance from the quarter-section corner at H, equal to $\frac{20.00}{41.50}$ of the distance from that corner to the township corner at A, as determined by actual measurement.

The quarter-quarter corner at k should be located on the quarter-section line $F\,B$ at the proportionate distance from the corner at o, the center of the section. For the original measure of the distance from the corner at o to the quarter-section corner at B on the township line, a mean between the distances $D\,C$ and $H\,A$, as given in the field notes, should be taken.

The corner at m is located on the quarter-section line at the proportionate distance from o, and, likewise, the corner at f is located on the section line at the proportionate distance from F, thus determining the position of the line $f\,m$. The corner at e is

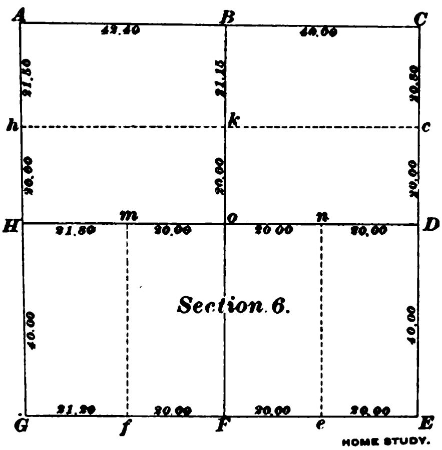


FIG. 2.

located on the section line midway between E and F, and the corner at n is located on the quarter-section line midway between D and o. In locating these corners, the entire distance from E to F, and from D to o, is measured, and each corner located at one-half the distance, whatever it may be.

In measuring a line for the location of a corner, either midway on the line or at a proportionate distance from one corner, a temporary stake should be set on the line, when measuring it, at what will be the position of the corner in case the measurement is found to correspond with the original measurement. Then, when the entire line between the known corners is measured, this stake can be moved ahead or back, according as the measurement is found to overrun or fall short of the original measurement, the proper distance to place it in the true position of the corner. This obviates measuring

one-half the distance a second time, and, as the position of the corner will be fixed by continuous measurement, all made at the same time, the measurement will be likely to be uniform and involve comparatively little error. Thus, in the example given above for locating the corner at B, in measuring from C to A a stake is set at 40 chains. The measurement of the entire distance CA is found to overrun, so that the proportionate distance from C to B is 40.50 chains. Hence, the true position of the corner is 50 links forward, or toward A, from the temporary stake set at 40 chains.

GREENHOUSE HEATING.

Thos. N. Thomson.

GREENHOUSES SHOULD BE MORE COMMONLY USED—HOW TO BUILD A SMALL LEAN-TO CONSERVATORY—HOW TO DETERMINE PROPER SIZE OF BOILER, AND COMPUTE PIPING REQUIRED.

FLOWERS are loved by all—in childhood, in youth, and in old age. We always welcome and adore the beautiful and fragrant blossoms, whether in the meadow, on the street, or in the sick chamber. Look at the little children as they merrily pick the buttercups and daisies from the neighboring fields or vacant lots and bring them home for "mamma" to put in water! The boys and girls at school are, of course, beyond the stage of buttercups and daisies, but watch them hunt for the trailing arbutus, the sweet-scented honeysuckle, the delicately tinted laurel! Take notice of the rising generation in its teens and twenties—the beau with his boutonniere, the belle with her bouquet! And the benedict is just as susceptible as anybody else, for he cannot take a walk on Sunday without bringing home some beautiful floral trophy of the field with which to decorate the table. Yea, even the close, shrewd, business man—the man whose mind is full of dollars and cents from Monday morning to Saturday night—sometimes gives way to the temptation of the little florist's store on the corner, and goes in to order that some geraniums, fuchsias, and a few other pot plants be sent to his home at once.

Then there are the "old folks," who have been changing physically and mentally for sixty years or more, and have formed many likes and dislikes. They are, as we say, set in their ways; but their love of flowers has never changed. Nothing apparently pleases the aged—the most highly honored and respected people of our nation—more than to sow seeds, raise flowers, and enjoy their presence and the pleasure they give to the younger generation. Truly, we are a nation of flower lovers. Why should it be otherwise? A love of flowers betokens civilization. Go where you will, you will always find that the more refined and cultured families can be distinguished by the flowers in the windows, gardens, or conservatories. The only trouble is that there is not enough provision made for saving the beautiful plants that annually go to waste in the fall of the year.

Nearly every well-to-do mechanic in the country towns and villages, and in the suburbs of our great cities, has a flower patch, which buds and blooms all summer long. The plants are carefully nursed, and grow

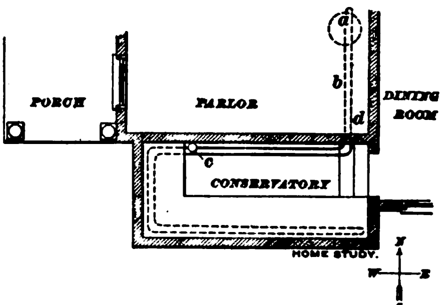


FIG. 1.

more beautiful every day, until some blasting, bitter wind comes along—betokening the approach of winter—and cuts them off in their prime. They never looked better than they did the day before, and now they are ruined for ever; the results of a summer's labor are destroyed. Why this constant sowing of seeds in the spring, coaxing and nursing of tender plants during the summer, and ultimate destruction of the full-grown beauties in the fall every year? Why are not these flowers lifted and removed to a place of shelter, and kept for winter decoration and pleasure? Simply because the average

family has no place to keep them, except in the living rooms of the house, and we all know the objections to keeping them there. Doctors tell us that it is unhealthy to keep flowers in the house, and we ourselves know that they must be sprinkled periodically and watered regularly to keep them alive. The products of combustion from oil and gas flames, and sulphurous gases from the stove or furnace, tend to kill the house plants during winter. Then, again, they become infected with insects and small vermin, and require to be fumigated occasionally ; while last, but not least, they cannot usually get enough sunshine, and so become almost useless for outdoor planting in the spring.

What is wanted, then, is a more general use of houses or apartments especially constructed for the purpose of horticulture ; and they must be made of glass. True, there are many such houses dotted all over this vast country, but they belong to the wealthy, or to such of the general public whose business or hobby is horticulture.

Now, there is no reason why the pleasures of winter floral decorations should be confined to the wealthy ; the industrious every-day mechanic can have the same thing, only on a smaller scale. The rich man can have his isolated greenhouses and conservatories, and no doubt can propagate and grow what he pleases, from mushrooms or forget-me-nots, up to century plants or mammoth palms. He can have, and very often has, separate greenhouses for different purposes, such as carnation and chrysanthemum houses, vineries, palm houses, roseries, propagating houses, etc., all of which, however, do him no more good than a small general greenhouse does the family of the business or working man.

The cheapest and perhaps the most desirable form of greenhouse is a simple "lean-to" glass building, connected to the house—something like that of which a floor plan is

Fig. 2.

to be. A small cast-iron boiler *a* is set in the cellar near the chimney. A flow main *b*, of 1½-inch black-iron pipe, is run from the top tapping of the boiler to the expansion tank *c*. A coil of four 1½-inch pipe runs from the tank and under the flower-pot benches. The lower end of the coil is continued full bore around the back of the greenhouse, and goes through the foundation wall into the cellar, and then connects to the bottom tapping of

the heater, thus forming the return pipe *d* for the system. The floor pipe and all the other pipes must grade upwards towards the tank with a pitch of not less than 1 inch in 10 feet, and all pipes must be supported, so that they will not sag, because if they are not properly graded, or if they sag, air bubbles will gather in the pipes and stop the circulation of the water. With the arrangement shown, all air bubbles will escape at the tank.

The reason why the tank is placed on the flow-pipe line, instead of on the return line, is to prevent the water from being blown out of the system if the heater should generate steam; also, to allow a free escape of vapor, if necessary, by removing the loose cover of the tank during severely cold weather. This vapor will condense on the glass and freeze, thus forming a skin of ice, which not only closes the laps in the glass, but also forms a medium which helps the glass to prevent loss of heat by radiation and conduction.

Any man who is handy with tools can easily and very cheaply build a "lean-to" green-house for himself in the evenings, and if he has stocks and dies he can readily install the heating system himself.

To determine the amount of pipe surface in square feet required to maintain any desired temperature in a greenhouse during zero weather, the following table should be referred to:

Temperature Desired in Greenhouse.	Square feet of Glass and its Equivalent Proportioned to 1 Square Foot of Surface in Heating Pipes.			
40°	4.33	5.25	6.66	7.7
50°	3.07	3.93	4.76	5.7
60°	2.19	2.90	3.63	4.33
65°	1.86	2.53	3.22	3.84
70°	1.58	2.19	2.80	3.44
Temperature of Water in Heating Pipes.	140°	160°	180°	200°

About 4 or 5 square feet of exposed wall surface should be considered eqivalent to 1 square foot of glass.

To find the size of heater required to properly heat a greenhouse having less than 500 square feet of glass—that is, about 150 square feet or less of hot-water radiation—divide the radiation by 10 to determine the proper area of flue-heating surface in square feet which the boiler should contain; or, if it is a direct-heating surface boiler, divide by 30 or 40.

To find the grate surface in square feet, divide the number of square feet of radiation

FIG. 3.

by about 200; in no case, however, should the grate area be less than ¼ of a square foot.

To determine the capacity of the expansion tank above the pipe connections, divide the entire capacity of the heating system by 20.

The pipes should always be large—never less than 1¼ inches. In the best of greenhouses 4-inch pipes are used. Fig. 3 shows how 4-inch pipes are usually employed for heating a greenhouse. Five of them in all—two flow pipes *a*, *a* on top, and three return pipes *b*, *b* below—run the whole length of the benches, and are supported, at intervals of about 8 or 10 feet, by brick piers *d*. They are set in cast-iron chairs *c* and are staggered as shown, so that the air in flowing up between the pipes *b*, *b* must touch the upper pipes and thus become heated.

As the air near the glass is the coldest air in the house, it is advisable to keep the benches out from the wall a few inches, as at *g*. This allows the heated air from the pipes to flow freely up between the plants and the glass. If the benches are set close back to the wall, the plants next to the glass will surely freeze during very cold weather.

To prevent a down draft at *g*, and, in fact, to compel the warm air to flow up *g* in spite of the counteraction of a cold-air current at the glass, the face plate, or board *f*, should hang about 4 or 6 inches below the bench planks.

LUBRICANTS.

H. Rolfe.

THE THREE MAIN GROUPS OF OILS AND FATS: ANIMAL, VEGETABLE, AND MINERAL—SOURCES OF PRODUCTION—HOW OBTAINED—FOR WHAT PURPOSES THEY ARE USED.

IN choosing a lubricant for any particular kind of work, considerable care has to be exercised; different conditions necessitate different qualities in the oil used. Undoubtedly, as a rule, consumers do not pay sufficient attention to the question of suitability in the oils they use. The bare fact of a fluid being *greasy* is by no means a guarantee that it is fit to be used as a lubricant.

There are three ways in which a bad or unsuitable oil will eventually make its presence felt in the expense sheet of the concern using it:

1. Extra wear of parts, necessitating constant renewals and repairs.
2. Extra coal or other fuel used to overcome the extra friction accompanying the extra wear.
3. Extra oil consumed.

In textile mills, containing many hundreds of shaft bearings, the expense due to the above considerations is doubtless very considerable. In very heavy stationary engines and also in large marine engines, number 3 is more likely to be the chief item for consideration.

In railroad rolling stock, the matter of wear is, by some, usually regarded as the heaviest item, but wear will always be rather pronounced with rolling stock as compared with mills, etc., whatever the lubricant, owing to the large amount of grit and sand picked up along the road. The nature of the track itself is a distinct factor in the case, some roads that are very sandy causing much more rapid wear of the various brasses and bearings than other roads.

It may be due to the purchaser's carelessness, or to his inability to readily refute the drummer's statements, or it may only be a coincidence, but it is, at any rate, probable that there is more swindling done in connection with lubricating oils than with any other engineering material. There may possibly be some inherent attractiveness in the oil itself that allures the swindler to exercising his arts upon it; at any rate, just as some particular stocks are great favorites with the gamblers on 'change, so some kinds of lubricating oils seem to lend themselves to the operations of the unrighteous. However, the favorite methods of these swindlers have been pretty well exposed from time to time in the various technical journals.

The purpose of this article is simply to try and put the consumer in the right path for exercising some check on the seller, and seeing that he gets an oil that not only fulfils what is claimed for it but is also suitable for the work for which it is intended.

First, however, some remarks will be made on lubricants in general, mentioning the various sources from which they are derived.

Lubricants may be divided into three groups:

1. *Fluids*, such as the various oils.
2. *Solids* under ordinary temperatures, as tallow, etc.
3. *Solids* proper, as plumbago, metaline, etc.

Group 1 comprises three classes, animal, vegetable, and mineral oils. In group 2, we have beef and mutton tallow, suet, and also wagon grease. In group 3, are plumbago (also known as graphite, or black lead) soapstone, and various antifriction compounds; in this class, too, might also come the various antifriction alloys, which, to a greater or less degree, do what is claimed for them.

The *animal oils* chiefly used are lard oil, neat's-foot oil, and the various fish oils, as sperm and seal. Of less general use are whale, porpoise, walrus, and sturgeon oils; the extensive use of cod-liver oil, in medicine, is well known; whatever may be its lubricating purposes, its value for medicinal purposes is still greater—pecuniarily.

It may be mentioned, in passing, that people have always contrived to make use of whatever animal life was at their command for the purpose of obtaining oil and grease, the more uncivilized races using the products chiefly for cooking, lighting, and anointing the body. For such purposes, various peoples have pressed into their service such

things as ants, beetles, bats, and cockroaches; and among the bird tribes, the pheasant, pigeon, peacock, penguin, and ostrich; the use of goose grease also is of very old standing, it being considered a very valuable remedy for sore throat, etc. Also may be mentioned bear's grease, that was at one time largely used by barbers, the genuine article being regarded as of great value in treating the hair.

The *vegetable oils* largely used for lubrication are olive, rape, castor, cottonseed, linseed, and palm oil, the last one being chiefly used in the manufacture of axle grease. There are many other sources of vegetable fats, which seem, however, to be used by the natives more for food and lighting than for lubrication, possibly because they have nothing to lubricate; in parts of India and China a kind of vegetable tallow is obtained from the tallow tree, while Africa possesses something similar in her "butter tree." Nearly all tropical countries, in fact, possess plants whose nuts and seeds yield wax and fat. At home we have corn oil, much used in soap making, and also oil produced from the seeds of the sunflower, to say nothing of that obtained from the peanut and cocoanut. The last named is found in the West Indies and in South America; it is used in candle and soap making, but out in the East Indies the natives use it for food, lighting, and medicinal purposes; it is said to be a good illuminant, as it makes no smoke.

The *mineral oils* are derived chiefly from the petroleum wells in the United States and Russia; they were formerly distilled from peat and also from coal tar, but the extension of the petroleum industry has diminished their importance.

Some account will now be given of each of the above oils and the method of production, after which something will be said of the properties of lubricants in general and the tests to be applied.

Lard Oil.—The United States are the largest producers of lard; the yield per hog is between 30 and 40 pounds. The lard is extracted by putting the "leaf" into iron tanks or boilers and injecting steam at 70 pounds pressure or more. The oil is obtained from the lard under hydraulic pressure; the lard in its solid state is put in woolen bags and then in wicker baskets and left under a pressure of from 1,000 to 1,200 pounds per square inch at a low temperature. The oil—known as *olein*—is thus expelled, 100 pounds of lard yielding about 60 pounds of the oil. It is a very valuable lubricant, but is also used for adulterating purposes; it is said that the French adulterate their olive oil with it very extensively. The solid parts left in the press are used in soap making. Cincinnati is a large producer of lard oil.

Neat's-Foot Oil.—This is prepared from the feet of oxen. The leg bones are cut off 16 to 18 inches above the hocks and the oil extracted by boiling, ten of the feet yielding about a quart of oil. The best oil is obtained from the tissues in the hoof. It is limpid at temperatures as low as 32° F. and is very useful for lubricating clocks and also for bearings exposed to the cold.

Whale Oil.—The growth of the mineral-oil trade and the substitution of steel for whalebone have caused the whaling industry to decline. At present the United States carry on the largest trade. The varieties of whale hunted are the Greenland whale, yielding about 120 to 130 barrels of blubber, the Polar whale, giving 90 barrels, and the southern, or cape whale, which produces about the same amount. The blubber is from 10 to 20 inches thick and resembles tough, fat pork. It is cut up in pieces and the oil drained out of it. The oil is then heated to about 220° F. to remove part of the odor and also to assist in clarifying it, after which it is cooled off and put up in barrels. The sperm whale is found in the Pacific and Indian oceans; from its head is obtained the spermaceti, so much used in candle making; an average yield is 45 barrels. The origin of this word spermaceti (from the Latin words *sperma* and *cetus*) seems to imply that it was originally thought to be the spawn of the whale.

Porpoise Oil.—This is highly esteemed, as it gives a light without smell; congeals only in intense cold, and is of much value in leather dressing, besides which, it also has good lubricating properties; a full grown porpoise gives from 400 to 450 pounds of oil.

Seal Oil.—Seals are, as a rule, caught merely for their skins, the carcasses being neglected; there is a good yield of oil to be obtained from them, however, a mature seal giving close to 300 pounds of blubber, from which 20 to 25 gallons of oil are obtained. From a larger variety found in the Russian fisheries, 350 pounds of blubber can be obtained.

Shark Oil.—Shark hunting is carried on pretty vigorously for the sake of the livers, which yield a good supply of oil said to be nearly as good, medicinally, as cod-liver oil, for which, in fact, it is often substituted.

Walrus Oil.—This is not so much esteemed

as porpoise oil. About 20 to 30 gallons are obtained from one animal.

Olive Oil.—The olive tree is principally cultivated in the eastern world, and seems to flourish on dry, sandy, and rocky ground and thus enables districts to be utilized that would be valueless for other products. The fruit is first crushed, the pulp thus formed being put into bags and subjected to pressure at a warm temperature. The presses are, nearly always, the old-fashioned screw variety, though where the people have been fortunate enough to come in contact with the hydraulic press, it is of course used. After getting a supply of oil—known as virgin oil—by simply pressing, the stuff is well mixed with boiling water and then again pressed and more oil coaxed out of it. Any oil then left in the fruit husks is extracted by chemical means. The best qualities of olive oil are sold as "salad oil," and are also used for packing sardines in. Olive oil is much adulterated with palm and cottonseed oil.

Rape Oil.—This is very extensively used for machinery and engines; it is extracted from the rape seed, which grows in the East Indies and in some parts of Europe. It is known also as colza oil.

(*To be Continued.*)

THE STUDY OF INSECT LIFE.*

Adam Kaufman.

The Two Principal Methods of Preserving Entomological Specimens—Value of a Good Note Book—Labeling—Classification—Systematic Work Necessary.

THERE are, in general use, two methods of preserving entomological specimens. One is to pin and dry, the other is to place in some preservative liquid. The method to be chosen depends greatly upon the nature of the specimen and the use to which it is intended to put it. As a rule, any specimen that will maintain its shape may be pinned and dried. On the other hand, the immature forms of all insects, and such adults as have soft bodies that shrivel up while drying, are usually placed in alcohol. Millepedes, centipedes, mites, spiders, and forms allied to these, are also preserved in alcohol. Some small insects, on account of their minute size, are mounted in Canada balsam upon glass slips, so that they may be examined by aid of the microscope. For anatomical study, specimens are always preserved in alcohol or some other preservative liquid.

The appearance of a collection of insects greatly depends upon the care that is taken in pinning and arranging the specimens.

We will suppose that the reader has pinned and spread a few insects according to the method described in the first part of this article, and now wishes to know something about labeling and classifying them.

In making a collection of insects, it matters not how much care and pains are taken in preparing and mounting the specimens, the collection will be of little real value unless each specimen is properly labeled, with information as to locality where found, date of collecting, name of collector, and reference to note book, if any biological or other facts concerning the specimen have been ascertained and noted. The collector should therefore adopt some definite system of taking notes and labeling; and it is very important that the system be a simple one, in order that it can be easily carried out.

The number of specimens that a collector of insects must handle is so great that it is impracticable to give each specimen a number referring to a note book. It is a good plan, however, to number those specimens of which you intend to make a special study, by having a serial number which refers to a note-book record giving date of rearing or collecting, locality where found, food plants, life history, and any other facts of interest.

The labels generally used, Fig. 11 (*a*), are as follows:

(1) *Locality label.* This should be as explicit as possible.

(2) *Number and date of capture.* This is not only very useful but is often quite important, in various ways. It indicates at what season of the year additional specimens of the same kind may be secured, and greatly assists in elaborating the life history of the species. In other cases it assists in the

* *Begun in the August Number.*

correct determination of closely allied insects which differ chiefly in habit or date of appearence.

(3) *Name of species and symbol indicating sex.* The use of a symbol for indicating sex has recently acquired greater importance than it formerly possessed, on account of the value of the sexual difference in the distinction of the species. The symbolic signs for male, female, and worker are shown at (*b*) Fig. 11.

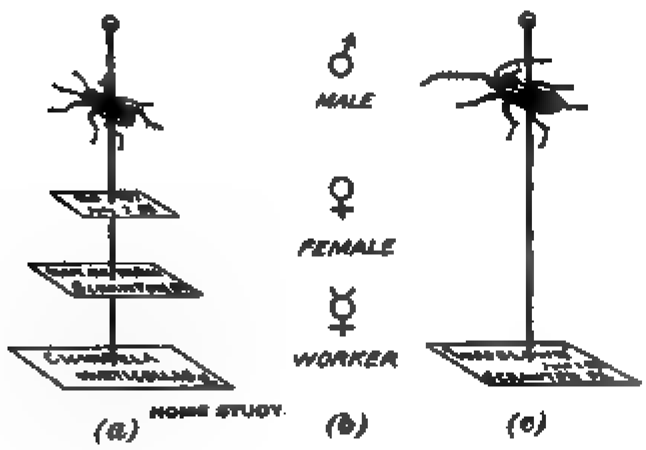


FIG. 11.

Entomologists who wish merely to record the locality and date of capture, make use of a small label which is placed on the pin below the specimen, as at (*c*) Fig. 11.

One of the prime characteristics of insects is that of segmentation. The word "insect" signifies this, being derived from the Latin word *insectum* which means *cut into.* This feature of having the body divided into rings, or segments, by transverse incisions is possessed by other large groups of animals. All animals possessing this characteristic are classed together as the *Arthopodal* branch of the animal kingdom, the term "branch" being applied to each of the principal divisions of the animal kingdom. This branch is again divided into four classes, one of which, the *Hexapoda*—which means having six feet comprises the insects.

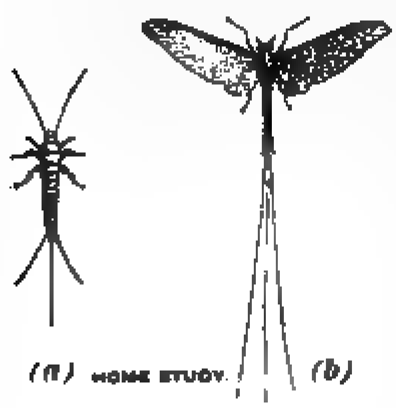


FIG. 12.

As a rule, the body of an insect is composed of seventeen segments, which are arranged in three regions, namely the head, thorax, and the hind body, or abdomen. The thorax bears two pairs of wings, and three pairs of jointed or segmented legs. Insects breathe by internal air tubes opening externally by spiracles. The growth of an insect is either by direct development or by undergoing a complete metamorphosis, namely from the larval to the pupal stage, and from the pupal to the adult stage.

The class *Hexapoda* is divided or classified into orders, families, genera, and species. The study of the classification of insects is called *Systematic Entomology.* As regards existing forms, this class is divided into sixteen orders:

FIG. 13.

1. Thysanura,	9. Hemiptera,
2. Ephemerida,	10. Coleoptera,
3. Odonata,	11. Neuroptera,
4. Plecoptera,	12. Mecoptera,
5. Platyptera,	13. Trichoptera,
6. Dermaptera,	14. Lepidoptera,
7. Orthoptera,	15. Diptera,
8. Thysanoptera,	16. Hymenoptera.

1. *Thysanura: Bristletails, Springtails, Fish-moths, Etc.*—The members of this order are very primitive forms; they are all wingless, and undergo no metamorphosis. They are mostly small insects, and usually live in damp places under stones, though the bristletails, Fig. 12 (*a*), prefer warm, dry places.

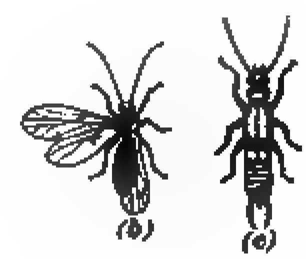


FIG. 14.

2. *Ephemerida: May-Flies.*—These insects have delicate membranous wings, with a fine network of veins; the front wings are large and the hind wings quite small. The mouth parts are rudimentary. The abdomen is long, soft, and terminated by two or three many-jointed, thread-like

appendages. A May-fly is shown at (*b*), Fig. 12. This may be found during the warm evenings of late spring or early summer flying around electric and other bright lights.

3. *Odonata: Dragon-Flies.*—The dragon-flies, Fig 13, have large heads; the eyes in the typical forms are enormous, while the antennæ are minute. The thorax is large and round, the abdomen is very long and cylindrical, ending in a pair of claspers in

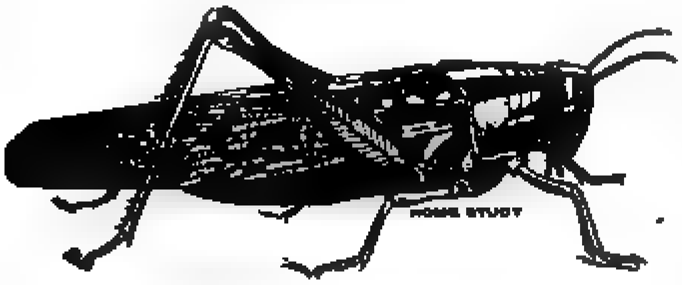


FIG. 15.

the male. The wings are large and densely net-veined, the hinder pair being often a little larger than the front pair.

4. *Plecoptera: Stone-Flies.*—This order includes the single family stone-flies, see Fig. 14 (*a*). They have four membranous wings with many or comparatively few cross-veins; the hind wings are much larger than the front wings, and are folded in plaits, and lie upon the abdomen when at rest. The mouth parts are of the biting type of structure, but are frequently poorly developed.

5. *Platyptera: White Ants, Book Mites.*—The members of this order are social insects; only the "kings" and "queens" are winged. These have four long, narrow wings, similar in form and structure, which, when at rest, lie flat across the back; see Fig. 14 (*b*).

6. *Dermaptera: Earwigs.*—The front wings of the earwig, Fig. 14 (*c*), are small and leathery; the hind ones look like a fan when

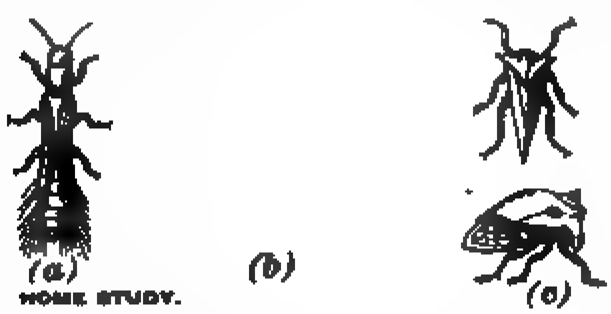


FIG. 16.

opened, and the characteristic feature is a pair of forceps-like appendages at the end of the body, best developed in the male. They are nocturnal in habits, hiding during the day in any available recess.

7. *Orthoptera: Grasshoppers, Crickets, Cockroaches.*—Some of the best known insects belong to this order. They are characterized by having the fore wings straight, and usually narrow and parchment-like, thickly veined, and overlapping at tips when closed; the hind wings are large, and fold longitudinally, like a fan, Fig. 15.

An insect of this order has a lengthened body, large head, and its mouth parts are formed for biting. The legs are strong, and fashioned either for grasping, running, climbing, jumping, or burrowing.

8. *Thysanoptera: Thrips.*—To this order belong the minute insects commonly known as thrips, Fig. 16 (*a*). They feed on plants—puncturing and killing the leaves—or on other plant-feeding species of their own class. They have narrow wings, beautifully fringed, which are crossed on the back when at rest.

9. *Hemiptera: Bugs, Lice, Aphids.*—The members of this order are divided into two suborders:

The *Heteroptera*, or half-winged bugs, Fig. 16 (*b*), have the first pair of wings thickened at the base, with thin membranous extremities which overlap at the back. The wings cross flatly over the back when at rest.

The *Homoptera* have all four wings of a uniform membranous thickness throughout;

FIG. 17.

these usually slope, roof-like, at the sides of the body, when at rest. The mouth parts are beak-like, rising from the hind part of the lower side of the head, Fig. 16 (*c*).

This order includes many well known pests, among them the true bugs, the lice, the aphids, and the scale insects. Some species have the power of emitting, when disturbed or alarmed, a foul-smelling odor. To this order also belong some well known aquatic insects, such as the "water boatmen," "water scorpions," "giant water bugs," etc.

10. *Coleoptera: Beetles.*—The ease with which the insects of this order are obtained and preserved make it one of the most attractive to the amateur entomologist. The beetles, Fig. 17 (*a*), or shield-winged insects, are, perhaps, of all insects, the best known. They differ from other insects in the nature of the fore wings, which are usually thick, horny, veinless wing covers called *elytra*, which meet in a straight line down the back,

and beneath which there is a single pair of membranous wings. The mouth parts are well developed and formed for biting.

Coleoptera may be found in all climates and in all localities. They may be found in the highest northern latitudes and in the tropics. The early spring is the best time for collecting them, as then many species fly about, especially towards evening. On favorable days the number of specimens and species that can thus be found is astonishingly great, and this is one of the few occasions when the collector can advantageously use a butterfly net. The flying beetles generally alight on the tops of fences, where they can be easily seen and secured.

Many species of beetles may be found by digging in the ground at the bases of large trees, under old logs and stumps, also by turning over stones, and under the loose bark of certain dead or dying trees, such as pines, maple, beech, shellbark hickory, etc. Meadows and low herbs invite the use of the sweeping net. Branches of trees and shrubs may be worked successfully by beating them into an umbrella, but the success of this method depends greatly on the particular kind of tree or shrub, its condition and situation, and largely upon the season. Pine and young oak trees, at the edges of woods, are generally very productive.

11. *Neuroptera: Dobsons, Aphis Lions, and Ant Lions.*—The members of this order, see Fig. 17 (b), have four membranous wings furnished with numerous veins, and usually with many cross-veins. The head is not prolonged into a beak. The mouths parts are formed for biting.

12. *Mecoptera: Scorpion Flies.*—The four wings of the insects belonging to this order, Fig. 18 (a), are long, narrow, nearly equal in size, and membranous with numerous veins. The mouth parts are the most striking characteristic; they are prolonged in a rostrum or beak, at the end of which are the biting mouth parts. The abdomen of the male is constricted near its posterior end, and terminates in long, clasping organs, from which these insects obtain the common name "scorpion flies."

13. *Trichoptera: Caddis Flies.*—The caddis flies or moth-like insects, Fig. 18 (b), which belong to this order are commonly found in the vicinity of streams, ponds, and lakes, and are often attracted to lights at night. They have four membranous wings, furnished with numerous longitudinal veins, but with only a few cross-veins, and are more or less densely covered with hairs. When not in use they are folded in an almost vertical position against the sides of the body.

The larvæ of these insects live in silken cases at the bottom of quiet pools; the cases are covered with bits of sticks or grains of sand and are usually cylindrical in shape. The larva drags its case over the bottom of the

FIG. 18.

stream, or climbs up or down water plants, and feeds on decaying leaves and small insects.

14. *Lepidoptera: Butterflies and Moths.*—The members of this order are characterized by having four membranous wings, Fig. 19. The fore wings are the larger, and are triangular in general outline, while the hind wings are more or less rounded. The membranes of the wings are concealed beneath a covering of minute colored scales. The membrane itself is not colored, the colors of the wing being due to the various hues of the scales. These are arranged in regular rows and lap over one another like shingles on a roof. They are modified hair, and are of various shapes. The two sexes are often different on the upper surface, but are more nearly alike beneath.

The abdomen is either oval, slender, or

FIG. 19.

nearly conical, and is covered with fine scales and hair.

On the under side of the head are the mouth parts. These consist, first, of a three-jointed pair of palpi, which are densely covered with hair-like scales, and which project outward and often curve upward more

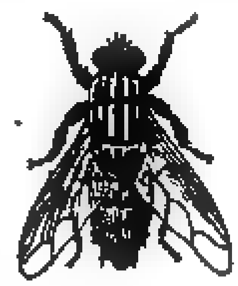
or less closely to the front of the head. Between the palpi, and attached to the head near the base of them, is the tongue. This is a long, tapering, horny tube, especially adapted for sucking nectar from flowers. When at rest, the tongue is coiled backward between the palpi, like a watch spring.

Butterflies are day fliers; they rejoice in the warm sunshine, few being seen on the wing if the weather is cloudy with a cold wind. When at rest, they fold their wings together above the back in a vertical position. The antennæ are thread-like with a club at the tip.

Most of the moths fly by night, and are frequently attracted to lights. When at rest, the wings are either folded together above the back, are spread horizontally, or are folded, roof-like, on the abdomen. The antennæ of moths are of various forms, usually thread-like or feather-like.

15. *Diptera: Flies, Mosquitoes.*—This is the only order, Fig. 20 (*a*), which has two wings, the hind pair being replaced by a pair of small, slender filaments, clubbed at tip, and are called *halteres*, or balancers. The wings are thin, membranous, and usually either naked or covered with very minute hair. The mouth parts are formed for sucking, and sometimes also for piercing. The larvæ are commonly called maggots. Most Diptera frequent flowers, and may be collected with a sweeping net without much difficulty.

16. *Hymenoptera: Bees, Wasps, Ants, Saw-Flies, Etc.*—These are characterized by having four membranous wings with comparatively few veins; the hind pair are the smaller, Fig. 20 (*b*). Some of the insects of



(*a*) (*b*) HOME STUDY

FIG. 20.

this order are highly specialized, and their mouth parts are fitted both for biting and sucking. The abdomen in the females is usually furnished with a sting, piercer, or saw.

The wings on each side are held together by a row of hooks on the front margin of the hind wing. These hooks fasten to a fold in the hind margin of the front wing, so that the two wings present a continuous surface.

The insects of this order are chiefly of small or moderate size, and many of them abound wherever flowers bloom.

PHOTOGRAPHY FOR AMATEURS.

George F. Lord.

THE PLATE HOLDER—LOADING—FOCUSING—EXPOSURE—DEVELOPING, WASHING, AND DRYING.

PART II.*

BEFORE loading our plate holder, we will observe its construction. This should be done in broad daylight and every feature of the holder should be thoroughly understood before making use of it. It consists essentially of a box, or frame, with a chamber for the plate, and a slide to cover or uncover it at the proper time. The slide is withdrawn before making an exposure, and this operation, when carelessly done, is the cause of many a fogged plate. The reason for this will be clear when the construction of the holder is understood. The slide passes through a slit in the frame, which slit, on the withdrawal of the slide, is closed by a thin sheet spring. If the slide is not drawn out straight, but leaves the holder as shown in Fig. 1, the spring is held open, light is admitted, and the plate spoiled. There is evidently a similar chance of fogging the plate when *replacing* the slide, after exposure. Plate holders are commonly made "double," that is, to hold two plates. There is in every plate holder a device for holding the plate secure in its chamber; but as there are several different devices, and we do not know which one your holder uses, you must find out for yourself how it works; it is always very simple.

The slides are generally marked or colored

* *Part I Appeared in the July Number.*

to distinguish the back from the front; the back is usually black, the front colored. It is also very necessary to number the sides of the plate holder. After a holder has once been used, it is a safe rule never to open it

Fig. 1.

outside of the dark room. It may or may not be loaded, but, as with a gun, it is not wise to look into it to find out its condition.

As we are probably impatient to try our camera, we will proceed to load the holder. Having lighted the red lamp, and shut and locked the closet door, we will open a box of plates. Plate boxes are usually made of three parts, or covers, each outer cover fitting tightly over the next inner one. A sheet of paper covers the opening on the back. By running the thumb nail or the blade of a pocket knife along the crease, the top is loosened, when the two outer covers can be removed. The plates themselves are wrapped in black paper; when this is folded back the plates are seen. They appear white under the red light, although they are really a greenish yellow. They are packed in pairs, with the sensitized surfaces laid together, to protect them from abrasion. The sensitized surface can be distinguished from the other by its dull appearance; this surface should never be touched with the fingers. It is a good plan to brush or blow off any dust that may be on the plate or in the holder. If a brush is used, it should be a very soft one—camel's hair or sable—so that the surface will not be scratched. If you have no brush, blow on the plate from the side; not from directly over it, as any moisture from the mouth will spot the negative. The plate should be placed in the holder dull side *out*, and the slides should have their colored sides outward. Both sides being loaded, we make sure that the plate box and plate holder are both tightly closed, blow out the red light, and, taking up our camera, tripod, and holder, start out for our first experience.

Now, if the amateur will but keep cool, and take time to think and follow directions, it is almost certain that his first negative will yield satisfactory results. It often happens, however, that in his enthusiasm he "forgets things," and then his first attempt is a flat failure; though, to be sure, if the negative, on development, reveals a few light and dark parts, he is usually elated at his progress in the art.

In this venture, we will not attempt a portrait, as that is about as difficult an undertaking as could be found. Neither will we attempt to get a "shot" at the family cat, but select, for practice, some inanimate, motionless object.

Suppose we try the lilac bush in front of the house.

Screwing together the camera box and tripod, in such a way that one leg of the

Fig. 2.

tripod extends directly forward and the other two sidewise, as in Fig. 2, we open the shutter, cover the head with a black cloth, and look on the ground glass. Many beginners try to look *through the camera*, and are completely mystified because they don't see anything. The image is to be found *on the ground glass*, in all the beautiful colors of the object producing it. The first thing we

notice is that everything is upside down, and that all objects at the right in the view are at the left in the image, and vice versa. The reason for this is explained in HOME STUDY MAGAZINE, February, 1897, in an article entitled "Photography."

After becoming accustomed to this new order of things, we may distinguish our lilac bush, but it is all "blurry," in other words, "out of focus." To focus, we merely increase or diminish the distance between the lens and the ground glass until the image appears sharp. When this is done, we may find that the image is too large or too small. In the former case, we move the camera back a few feet and focus again. In the latter case, we move it forward. We will expose our first plate with the full opening or largest "diaphragm" of the lens. The bush is in the shade, but, as our lens is quite rapid, we will set our shutter to give an exposure of one second. Making sure that the shutter is closed, we place the holder in position, with slide No. 1 towards the lens, withdraw the slide, and release the shutter. The exposure being over, we replace the slide with the *black* side towards the lens, and remove the plate holder from the camera. We can now tell, from the appearance of the holder, that plate No. 1 has been exposed. Forgetting to reverse the slide will surely lead to double exposures on the same plate; it is not safe to trust to the memory. We never knew a photographer who had not, at one time or another, made a double exposure through omitting to reverse the slide.

As good judgment regarding the time of exposure is only gained by experience, we will try the lilac bush again, but this time we will use a diaphragm one-half the diameter of the former. We must remember, however, that the areas of circles vary as the *squares* of their diameter; thus, it will be seen the area $\frac{1}{2}''$ circle $=(\frac{1}{2})^2 \times .7854 = .19635$ sq. in.; area $\frac{1}{4}''$ circle $=(\frac{1}{4})^2 \times .7854 = .0490875$ sq. in.; and, therefore, our second diaphragm will admit but one-quarter as much light as the first, and we must expose the plate four times as long to get the same result. In order to vary the result we will allow an exposure of six seconds. This done, we may proceed to the development of the image.

On our return to the dark room, we first prepare the fixing bath, which is merely a solution of hyposulphite of soda, or "hypo," as it is generally called, in the proportion of 1 ounce of hypo to 4 ounces of water. Professional photographers usually keep a solution on hand, but we have found it satisfactory to dissolve it as needed.

In this case, having poured 8 ounces of water into the hypo tray, we add two ounces of hypo, which is soon dissolved. Washing our hands carefully, we mix the developer as follows: pyro solution, 2 drams; soda solution, 4 ounces; this we put in the 4 ounce graduate.

A word here about cleanliness. We have spoken of washing the hands after handling the hypo. This is very necessary, as the presence of the smallest quantity of hypo in the developing liquid will spoil the negative. No vessel that has contained hypo should ever be used for anything else connected with photography. Washing the fingers frequently is a good habit to get into when in the dark room. We now mix the bromide of ammonia solution: 1 ounce of bromide to 5 ounces of water. This we put in a bottle and place in a handy position; what it is for will be explained shortly. We then light the red lamp, take the plate holder, and shut and lock the door. Removing plate No. 1 from the holder, we place it in the developing tray, *film side up*, and pour the developer over it in such a manner as to quickly cover the plate. To do this skilfully requires a little practice: Take the tray containing the plate in the left hand, the graduate containing the pyro in the right; tip the tray downwards—away from you—slightly, and quickly pour on the developer, beginning at the lower edge of the plate and giving the tray a slight scoop upwards, so causing the developer to run up the plate and to cover the whole surface at practically the same instant. If any part of the plate is missed during the instant of pouring, it will show an unsightly mark. The tray must now be rocked slightly, in order that the developer may act evenly over the entire surface of the plate. No change is visible for a few seconds, but soon the image begins to appear in black and white. All that was light in the view is dark on the negative, and vice versa. On continuing the development, the surface of the negative gradually darkens, but on examining it by transmitted light, that is, by holding it between the eye and the lamp, the image is very distinctly seen. When to stop development is a very important matter, but the ability to judge the proper moment comes only with experience. The writer continues development until the dark parts of the negative are opaque to the red light, and small details are readily apparent. As soon as the plate is developed,

we rinse it in the dish of water and place it in the hypo to fix, and, as this is our first negative, we will watch the process carefully, by the red light. When placed in the hypo, the plate was almost opaque and the back of it was white. Soon, however, a change takes place; the white begins to disappear, and in a few minutes an examination of the back will show that the opaque whiteness has entirely disappeared. At this moment fixation is but half complete, however, and the plate must be left in the hypo twice as long, before it can be said to be *fixed*.

It must now be placed in a dish of cold water, in order to wash out the superfluous hypo. If this is not thoroughly done, the negative will gradually turn yellow and fade. Professional photographers have a washing box, provided with running water, which washes the plates very rapidly. As the process can be carried on in daylight, the amateur can probably find a place where he can wash the plate in running water for 15 or 20 minutes. Otherwise the negative must be placed in a dish of water, the supply being renewed every few minutes for about an hour. The negative is then removed and placed on the drying rack.

We are now ready for plate No. 2. After pouring the developer from the pyro tray back into the graduate, the second plate may be placed in the tray, and covered with the same solution. The image does not appear as rapidly on this plate as on the former; this is because we are using old developer, which is not as strong and does not act as quickly as when it is fresh. We find, however, that the contrast is greater. The reason for this is that this plate is a trifle overexposed. If it had been *seriously* overexposed, it would have developed very rapidly, but with very little contrast. In such a case we should have quickly added a few drops of bromide of ammonia, rocking the tray in order to effect an even distribution. This solution acts as a "restrainer," and retards development. If the plate had been badly *underexposed*, it would have developed very slowly, and would have been hardly worth bothering with, but might have been improved by adding more of the soda solution to the developer.

As soon as the second plate is developed, it is rinsed and placed in the hypo, fixed, and washed as before.

In photography, the development of the image is by far the most interesting operation, and the amateur who pays a professional to do his developing is losing a great deal of valuable experience, and will never be able to place much dependence on his own ability; for it is in the dark room that we discover our mistakes, and learn how to correct them. We do not advise any one to take up photography unless he intends to do his own developing.

On comparing the two negatives produced, we shall find that the second is much sharper than the first, and that objects in the extreme foreground and background are more clearly defined. We learn by this result that the smaller the diaphragm used, the sharper the focus; and whenever we wish to photograph objects at different distances from the camera, it is necessary to use a small diaphragm, and to give a long exposure. But when we wish to bring out one object in sharp contrast with its surroundings, a larger diaphragm is necessary.

The dishes used in developing should always be thoroughly washed, and placed in readiness for the next development. The drying of the negatives will take from two to ten hours, depending upon the condition of the atmosphere. The anxiety of the amateur to make his first print often leads him to hurry the drying of the negative, but the result is generally disastrous. It will not do to heat it, as the film will soften, and the dark parts contract, until all proportion is destroyed and objects become unrecognizable. Fig. 3 demonstrates the effect of too much heat on the negative.

Fig. 3.

In warm weather the negative should first be drained for a few minutes, and then placed near an open window where the air will blow over it. In cold weather it may be placed in a warm, dry room on a shelf, on edge, and film side out.

(*To be Concluded.*)

PICKLING OF FRUITS AND VEGETABLES.

Mrs. Henry Esmond.

THE PICKLING OF PEACHES, PEARS, GREEN TOMATOES, AND CUCUMBERS—TOMATO CATCHUP.

PICKLED fruit is a very pleasant change from canned fruit or preserves, as one is apt to tire of the excessive sweetness of the latter. Fruits that are pickled may be served either as a relish with cold meat or as dessert. The fruit should be firm and rather underripe than dead ripe.

Pickled Peaches and Pears.—The clingstone peaches are better for pickling than the freestone variety; as they are always left whole, they keep their shape better. Hard, dark-green pears or seckel pears, are the best kinds of pears to use. Pour boiling water over the peaches, let them stand for a few minutes, and you will find that the skin can be removed as easily as from a tomato. Pare the pears lengthwise, being careful not to spoil their shape; the seckel pears do not need to be pared. Always leave the stems on. For 8 pounds of fruit allow 4 pounds of sugar and 1 quart of the best cider vinegar. Use only stick cinnamon and whole cloves—a good-sized handful of cinnamon broken into pieces about 1 inch long, and ½ cup of cloves. Some people use brown instead of granulated sugar for pickles, but it is not as pure as the granulated, and its only advantage is that it is a little cheaper. Make a syrup of the vinegar and sugar, add the spices, and let it boil up once. Put in the fruit, not too much at once, and let it boil for 10 or 15 minutes, or until the fruit can be pierced easily with a fork. Skim well, take the fruit out, being careful not to break it, and put into glass jars. The jars should be standing in a pan of hot water to prevent their breaking. Sprinkle some of the spices in with the fruit in each jar. Let the syrup boil up once or twice, skim well, and pour it into the jars. Fill the jars full and screw on the lids immediately.

Tomato Catchup.—Do not wait until too late in the season to make catchup, or the tomatoes will be watery. The tomatoes that ripen in the hot, dry weather are the best. Cut ½ bushel of firm, ripe tomatoes in half; leave the skins on. Put them into a porcelain kettle and let them simmer slowly until the watery part is all cooked away. Be very careful not to let it burn or stick to the bottom of the kettle. Asbestos mats are a great help in making pickles, especially if you use a gas stove. It is almost impossible, in the latter case, to prevent tomatoes from sticking to the bottom of the kettle unless you place an asbestos mat under the kettle, when you will find that the tomatoes will not burn. When they have become quite thick, remove from the fire and strain through a wire sieve; be sure the sieve is fine enough to retain the seeds. Put the strained tomatoes back into the kettle, and add 2 tablespoonfuls of ground cloves, 1 tablespoonful of allspice, 2 tablespoonfuls of cinnamon, 2 teaspoonfuls of cayenne pepper, 1 cup of salt, 4 tablespoonfuls of mustard, and 1 quart of the best cider vinegar. Mix the ingredients thoroughly, and let the whole simmer slowly for 3 or 4 hours. Pour into pint bottles, seal while hot, and keep in a dark, cool place. Some people like the addition of onion; in that case, cook 1 onion, cut in halves, with the tomatoes before straining. Catchup is a great addition to a "cold-meat" tea or luncheon, and is a help when warming meats over. It gives a "smack" to gravies and sauces for meat that is cooked over a second time. It can also be used in the deviled mixtures that are manufactured in the chafing dish.

Green-Tomato Pickles.—Wipe ½ bushel of green tomatoes. Have ready a clean, new basket, set in a tub. Cut the tomatoes into slices about ¼ inch thick; put a layer of these slices in the bottom of the basket, sprinkle with salt, put in another layer of tomatoes and more salt, and so on until the tomatoes are all used. Let them stand overnight, and you will find that quite a good deal of water has come from the tomatoes, and run through the holes in the basket into the tub. Put the tomatoes into a porcelain kettle, add 6 onions, cut in slices ¼ inch thick, 5 quarts of good cider vinegar, 3 pounds of granulated sugar, ½ cup of white mustard seed, 4 tablespoonfuls of whole allspice, 4 tablespoonfuls each, of ground cinnamon, mustard, ginger, and cloves. Mix well, and cook slowly until the onion is tender—about 20 minutes. Shake the kettle every few minutes to prevent the contents from burning; the shaking takes the place of

stirring, the latter being apt to break the slices. When done, put into stone crocks, cover with a cloth, and keep in a cool place.

Cucumber Pickles.—Cucumbers for pickling come in three sizes, the small ones are from 1 to 1½ inches long, the medium size are about 2 inches long, and the large size about 3 inches long. The medium size are very nice, though some prefer the small ones. Pick over 300 medium size cucumbers, wipe clean and put them into a stone crock. Pour over them a brine made of 2 pounds of salt (1 quart) dissolved in enough water to completely cover the cucumbers—about 1½ gallons. Let them stand in this brine for 48 hours. Then pour off the brine and wash them in cold water. Throw away any that have dark spots on them; put them back in the crock. Put 2 quarts of water and 2 quarts of vinegar and a piece of alum the size of a walnut, into a kettle; let the mixture come to the boiling point and then pour it over the cucumbers and cover tight. Let them stand overnight, and in the morning take the cucumbers out and put them in small, stone, earthenware, or glass jars. Boil, for 10 minutes, enough vinegar to cover them and 1½ cups of mixed white mustard seed, whole cloves, allspice, and stick cinnamon. Tie these spices in a piece of cheesecloth so they may be removed. When the vinegar is boiling, pour it over the cucumbers. Cover with 3 or 4 thicknesses of cloth and tie down tight. If you prefer to have the spices in the jars, do not tie them in the cheese-cloth; a very nice addition is onion, particularly if you leave the spices in the jars. Cut 1 good-sized onion into thin slices and cook it with the vinegar.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Philippine Islands.

WHEN war was declared last April between the United States and Spain, it may safely be said that ninety-nine per cent. of our population knew little and cared less about the Philippine Islands. On May 2d, the country was startled by the announcement of a great victory on the other side of the world. A squadron of American vessels, after a few days' hurried voyage from the coast of China, had crept at dawn into an enemy's harbor, past silent forts and sleeping sentinels, and there had attacked and destroyed a fleet of warships which represented one-fourth of the naval strength of Spain. From that day onward, the Eastern Archipelago, which was the scene of this exploit, has been an object of deep interest in many quarters; atlases and encyclopedias have been in demand; and the names of these tropical islands have become household words. Mars, the god of war, always the great geography teacher of the world, has set us a new lesson.

Off the eastern and southern shores of Asia lies a continuous chain of islands, extending from Saghalien, near the coast of Siberia, to Tasmania, at the south of Australia, the island continent of the southern Pacific Ocean. Midway in this chain are the Philippines, named in honor of Philip II of Spain. They spring like a forest from the bed of a shallow sea, and spread from north to south for a thousand miles in the shape of a half-opened fan. Their number is unknown, and travelers' estimates vary widely—from 400 to 1,900! This group first became known to Europeans in 1521, when it was discovered by Fernando Magellan, a Portuguese navigator in the service of the king of Spain. Forty years later a colony of Spaniards settled in Luzon, and founded Manila, which, next to Goa, in India, is the oldest European city in the East. A part only of the area of the Philippines was conquered. A thin fringe of settlements grew up around the coasts, but the authority of the Spaniards did not reach far beyond the range of their guns. There was no central power among the natives, no common religion or tradition to bind the people together; so there was little organized resistance to be overcome. A limited degree of conquest sufficed the Spaniards for purposes of commerce, and that was easily accomplished. The Chinese had long been established there as traders; but Spain, in pursuit of the policy which was universal in the sixteenth century, drove them from the islands, and with them lost that part of

the population which was trained in skilled labor. The colony was to exist for the benefit of Spain alone, and trade with it was restricted to the mother country.

On the whole, however, Spain did not deal harshly with the Philippines, according to the standard of the time. There were no such massacres as disgraced the history of her South American colonies. The sword of conquest was followed by the Cross, and while religion, according to the fashion of the day, was in part *enforced*, yet, among its teachers were good and devoted men who conferred many benefits on the people; they taught them useful arts, and by degrees inaugurated a system of education which has been maintained and developed. Many of the young men of the present day study law, and the ancient and modern languages; while Spanish must be acquired by all who transact official business. The present government of Spain is rather repressive than oppressive. It regulates, with strictness, the intercourse of the natives with foreigners; heavy taxes are collected from them, but they are granted no share in the civil administration of their country. The religious orders own much property, and exercise dictatorial authority over all who come within the very extensive sphere of their influence. Two years ago, 70,000 Malays rose in rebellion, demanding the redress of many political grievances; and they claim, first and foremost, the banishment of those ecclesiastics who have misused their power. They claim, also, the elementary rights of freemen, liberty of public meeting and of the press, and some degree of representative government. The conflict was still in progress when the war with America began.

The resources of the Philippines are but imperfectly developed. Nature has been generous, as she usually is in tropical islands. The forests contain valuable timber; the soil is fertile, producing rice, sugar, coffee, hemp, tobacco, and many other articles of commerce in profusion; and the mineral wealth is believed to be great. Copper, iron, and coal have been discovered, and sanguine speculators predict that the gold fields of the Philippines will rival those of the Klondike, or Australia in her palmy days. At present, three-fourths of the foreign trade is carried on with Great Britain.

The climate is one in which white races can live with comfort. It varies considerably, for the northern and southern limits of the group are as far apart as are Philadelphia and Key West. The mean temperature in the cool season—from November to March—is 72 degrees; while in the hot season—from March to July—it is 87 degrees. During the intervening months—from July to November—the climate is unhealthy; this is the wet season, when tropical rains swell the rivers into torrents, flooding the low districts, and the violent storms, known as *typhoons*, cause devastation on land and sea. It is not only at this period of the year, however, that nature is at unrest. The Philippine Islands are of volcanic origin, and many of the volcanoes are still active. Eruptions, of which some have been severe, have taken place frequently since the date of the European settlement, and earthquakes are of common occurrence. These are the forces which are at work in the process of earth building. Recorded observations have extended over but a few centuries, yet during that time the contour of the surface of the islands has changed; masses of volcanic debris have been washed into the valleys by floods; lowlands have been upheaved; islands have been joined together; and the shallow ocean bed around them may yet rise above the waters to be the scene of the activities of a future race.

The inhabitants of the islands number from eight to ten millions, and include many varieties, from the lowest specimens of humanity to the domesticated European. It would appear that, in the distant past, the Malays subdued the aborigines, and took possession of their country; and that the Chinese, the Hindu, and finally the European arrived in succession, the newcomers in turn overpowering those who had preceded them. All these various races intermarried, and the result is a population widely differing in grade, in color, and in general characteristics.

Among all these varieties, the aborigines and the Malays are the most interesting. The former are found in the mountains, and in the remote parts of the islands, which have been little explored. Some have never been brought under Spanish rule, but remain independent; and they live more like animals than like men. They are a small, primitive people, very black in color; the adults are about 4 feet 7 inches in height, and 50 years is regarded as extreme old age. Their senses are as acute as those of a dog; they are roused from sleep by the slightest sound, and hide quickly like wild creatures of the forest. Their wants are few; they wander from one plot of land to another, and feed on rice and fruits. They are differentiated from the animals by the use of language, and by a

belief in a form of religion, of which, however, very little is known. They appear to worship the powers of the air, to fear evil spirits, and by their veneration of the dead to express their belief in a future life. Aboriginal inhabitants of a similar character are to be found in Southern India, and the dwarf races of Central Africa resemble them so closely as to suggest a common origin.

When the Malays subdued these aborigines, and drove them into the interior of the country, they chose for themselves the coasts and the lowlands for their principal abode. Physically they are a powerful race, and are dominant over the rest of the population, excepting those of European descent. Possessed of good natural endowments, they are capable of organization, and of united action, and they can exercise self-restraint and perseverance in pursuit of their ends. Yet, under excitement, they will abandon themselves to the most violent passion and fury (popularly known as the "amok" fever), and respect neither the life nor the property of their opponents. They are deficient in the ambition and enterprise which are essential to rapid progress in civilization. Perhaps this is the natural consequence of the long repression of their aspirations by the superior race with which they come into contact, who desire to keep them in a subject condition.

At the moment of writing, the future of the Philippine Islands is uncertain. It is probable, however, that, before this issue of Home Study Magazine is in the hands of the reader, peace between the United States and Spain will have been restored, and all doubt concerning it set at rest.

THE SPANISH-AMERICAN WAR.

June 22d, 1898. American troops landed at Baiquiri, Aguadores, and Juruagua. The Texas bombarded Cabanas. Loss, 1 killed, 6 wounded.

June 23d. The Spanish squadron, under Admiral Camara, started for the Philippine Islands. The Monitor Monadnock sailed for Manila.

June 25th. Engagement near Santiago. Loss, 22 killed, about 80 wounded. American flag was raised over Sevilla, 6 miles from Santiago.

June 27th. 4,000 troops sailed from San Francisco for Manila.

June 29th. General Merritt, military governor of the Philippines, sailed for Manila, with a detachment of artillery.

June 30th. Reinforcements sailed from Tampa for Santiago. 2,500 troops arrived at Manila, having taken possession of Guahan, one of the Ladrone Islands, en route.

July 1st. General Aguinaldo proclaimed himself President of the Philippine Republic. Fortifications at Aguadores attacked by land and sea. Battle before Santiago, continued next day. American loss, 231 killed, 1,284 wounded, 81 missing. Spanish casualties (estimated), 3,000.

July 3d. Spanish fleet, under Admiral Cervera, attempting to escape from Santiago harbor, was destroyed by the American fleet, under Admiral Sampson and Commodore Schley. American loss, 1 killed, 2 wounded. Spanish loss (Cervera's estimate), 300 killed, 1,600 prisoners. Attack on the harbor of Manzanillo by gunboats Scorpion and Osceola.

July 6th. Steamer Alfonso XII destroyed by gunboats Hawk and Castine.

July 7th. Hobson and the crew of the Merrimac exchanged for Spanish prisoners.

July 9th. Spanish squadron, under Admiral Camara, returned through the Suez Canal to the Mediterranean.

July 10th and 11th. Bombardment of Santiago by land and sea.

July 14th. Surrender of Santiago and the eastern end of Cuba.

July 16th. Spanish vessel, the San Domingo, laden with provisions, destroyed while running the blockade.

July 17th. The American flag was raised over Santiago. Formal surrender of General Toral and large number of prisoners of war, with arms and ammunition. Yellow fever among American troops before Santiago.

July 18th. Manzanillo bombarded, and 8 Spanish ships destroyed.

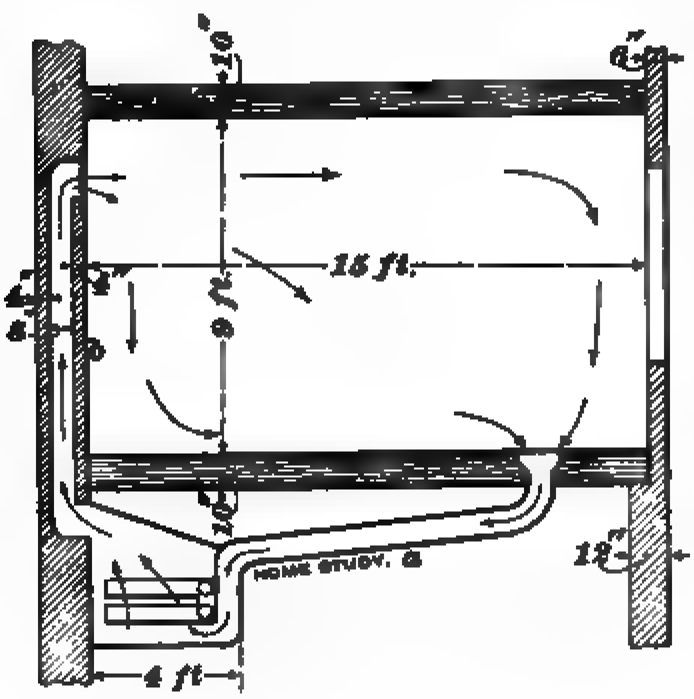
July 19th. Second detachment of troops landed near Manila.

July 20th. Troops sailed from Charleston for Porto Rico.

Our record closes on July 20th.

(337) (*a*) Can the first floor of a very large house be satisfactorily heated by indirect radiation from hot-water pipes? If so, how are the best results obtained? (*b*) I wish to take my supply of air for the stacks from the rooms to be heated. How can I do it? (*c*) Will a system of ventilation be necessary? If so, what system would you recommend—one that is not too costly (*d*) What is the correct way to figure hot-water radiation, both direct and indirect heating? I. R., Norwich, N. Y.

ANS.—(*a*) Yes. The best results are obtained in different cases by different methods and arrangements. To obtain the best result in any case, however, the following requirements must be obtained: (1) Sufficient heating surface must be allowed. (2) The circulation must be such as to insure a



proper temperature on every square foot of the heating surface. (3) The connections should be made without valves, if possible, so that there will be no danger of a novice shutting off the circulation, and thus allowing the stack to freeze and burst. (4) The stack should be arranged with a large airway between the surfaces, so that the air supply will be abundant. (5) The stack casing must be provided with an opening on the bottom for an inlet of cold air, and an opening on top for hot-air outlet. (*b*) You can accomplish this by connecting the cold-air duct *a* to the room at the floor level, and by running the hot-air pipe *b* up high enough to get a good draft before it enters the room, as shown in the figure. If you place the hot-air register flush with the floor, the air will circulate too sluggishly, unless the openings are very large. (*c*) No. The system you call for in question (*b*) is employed in order to avoid ventilation, and for that reason it is not desirable for warming living rooms. (*d*) We would advise you to read an article entitled "Heating," on page 127, of July, 1896, issue of HOME STUDY MAGAZINE. This will furnish you with all the information necessary to compute either steam or hot-water radiation.

(338) Here is a question given by the Civil Service examination for instrument men, which I am unable to understand. "Suppose you were required to give a grade line on a road such that the fills should balance the cuts, how would you proportion the respective quantities of for earth for rock, and what slope would you allow for cuts and fills?" Can you tell me what the question means, and how to answer it? E. D. T., Malden, Mass.

ANS.—We are unable to understand clearly what is meant by this question, and would consider its language quite indefinite and unsatisfactory for the purpose of Civil Service examination. We *think*, however, that what is intended is to ask how the relative quantities of cuts and fills should be proportioned for both earth and rock; or in other words, how much fill will be made by 1 cubic yard of earth or of rock measured in the cut, and what slope should be allowed in each case. Earth in embankment will always measure less than in the excavation from which the embankment is made; that is, the material will shrink. The amount of shrinkage will vary according to the nature of the material, the percentages of the shrinkage being about as follows: gravel or sand 8%; clay 10%; loam, 12%; and loose surface soil 15%. On the other hand, rock excavated and filled in embankment will measure from 25 to 85%, and usually from 65 to 75%, more in embankment than in its natural place before excavation—according to the character of the rock and the size to which it is broken. The slope of earth cuts should be $1\frac{1}{2}$ horizontal to 1 vertical for alluvial soils and similar materials, and may be as steep as 1 horizontal to 1 vertical for more stable materials. The slope of earth fills should be $1\frac{1}{2}$ horizontal to 1 vertical for all materials. The slope of rock cuts may be as steep as $\frac{1}{4}$ horizontal to 1 vertical for many kinds of rock.

* * *

(339) Will you kindly give me the best formula by which a spiral may be put in a 5° railroad curve, 362 feet long? G. N., Goshen, N. Y.

ANS.—This is too big a subject to deal with in these columns. We hope, however, at no distant date, to publish an article on spiral curves. In the meantime we suggest that you procure copies of "Engineering News," June 14, 1894, and October 29, 1896. In each of these numbers spiral curves for street railways is made the subject of an article, interestingly written and well illustrated. We think they will be a help to you.

* * *

(340) We are about to make quite a number of gear-wheel patterns. What is the quickest way to go about it? They are to be of wood. Is there any machinery for cutting the teeth? H. C., Kenauna, Wis.

ANS.—The teeth can be cut on an ordinary gear-cutting machine. The cutters must be kept very sharp, and be run at a good speed, the feed being slow. By setting to cut at a very slight angle, the necessary taper of the teeth can be given; a taper of $\frac{1}{16}$ inch in a foot is probably enough, which corresponds to an angle of about one-third of a degree. The patterns must be "built up," and the teeth may

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see contents page.

either be dovetailed in position on the rim and then finished in the gear cutter, or cut out of the solid wood blank. If the gears are small, cut cast-iron patterns are better than wooden ones, and may be obtained from any one of the firms who make gear cutting a specialty. Very large wood patterns are made by inserting the teeth and cutting by hand tools. Sometimes the teeth are finished first and then glued in position on the turned rim, the fillets at the roots of the teeth being glued on afterwards; the teeth must have a slight taper lengthwise. Unless you have a man who has had experience in making gear patterns, we advise you to have them made out, as it is a ticklish job.

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(341) Kindly tell me of a book containing full instructions for making a ¼-horsepower dynamo; also, a book containing full instructions for making a telephone suitable for a line 300 feet long. Give the price of each book, and tell me from whom I can procure copies. I want *simple* instructions written in language that is easy to understand.

H. P. D., Swift Falls, Minn.

ANS.—The Bubier Publishing Co., Lynn, Mass., will furnish you with a book giving instruction on how to build a ¼-horsepower dynamo or motor, together with all necessary castings, for $3.75. "Dynamo Building for Amateurs," by C. D. Parkhurst, price $1.00, can be had of The Technical Supply Co., Scranton, Pa. The latter company can also furnish you with the book "Practical Information for Telephonists," by T. D. Lockwood, price $1.00.

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(342) (*a*) Please give directions for constructing a small kite of the Hargrave cellular type, say 24 inches in height. I have made several kites, but cannot get them to fly. (*b*) Where can I get "The Practical Steam Engineer's Guide," by Edwards, and what is the price? W. R., Smith's Fork, Tenn.

ANS.—(*a*) We understand that you mean what is

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of cambric. The method of attaching the line *m* is by means of the "bridle" *a*, *b*, as shown in the figure. (*b*) From the publishers of this magazine, or from The Technical Supply Co., Scranton, Pa. The price is $2.50.

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(343) Your answer to Question 278 in HOME STUDY MAGAZINE for July, 1898, is very plain. I now want to ask another question regarding the belt from shaft *A* to shaft *B*. Suppose, when the belt is put on, that it is tightened up under a tension of 200 pounds. If, now, the belt is made to drive the 2-horsepower motor, will one side of it be tighter than the other, and does this tend to draw the shafts together, or is the load added to one side and subtracted from the other? WHALEBACK.

ANS.—One side will be tighter than the other, and the pull on the shafts will be increased—not to the full extent of the extra pull on the tight side, however, because the belt stretches, causing the pull on the slack side to become less than 200 pounds. While shaft *A* is driving shaft *B*, let T = the pull on the tight side of the belt, that is, the driving side, and t = the pull on the slack side. Then the force with which the shafts *A* and *B* are pulled together = $T + t$; and the force transmitted from the pulley on *A* to the pulley on *B*, due to the friction between the belt and the pulleys, = $T - t$. Many experiments have been made proving that these statements are true, but it has been found that there is no fixed relation between the increase of tension on the tight side of a belt and the decrease on the slack side.

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(344) (*a*) Why are bicycle racing tracks "banked"? (*b*) Is there any advantage in placing the crank-shaft of a bicycle below the center line of the wheels? Would there be any gain in placing them on or above this line? (*c*) What causes stars to "twinkle"?

H. S. H., Stroudsburg, Pa.

ANS.—(*a*) Tracks are "banked" to keep the rider's wheel from slipping out from under him. You have, of course, noticed that when rounding a curve the rider leans to the inside. He and his wheel tend always to move tangentially to the curve; he, however, turns the wheel constantly in the direction of the curve. But, if he were to do this, and at the same time try to maintain his upright position, he would fall off towards the outside of the curve, as his body would keep on in a tangential path. It is necessary then, in some way, to overcome, or at least counteract, the tendency to tangential motion. The rider does this by leaning inwards. If he were to do so when riding very slowly, he would fall off on the inside of the curve (if he did not turn his wheel to suit), but, when running at high speed, the two actions counteract each other. The higher the speed and the sharper the curve, the more the rider leans inwards. Now, if the track were horizontal, the wheel would slip outwards, as the necessary reactionary surface is not provided. The same thing would happen, in fact, if the man were riding *upright* on a sloping surface; the wheel would then slip downwards on the slope. The track ought to be set so as to always present a surface at right angles to the plane of the wheel. The sharper the curve, the more the track should be inclined. You have, perhaps, noticed how the degree of inclination varies in this way, the elevation being steepest at the sharpest corner; the rider, assuming his speed to be constant, has to lean inwards at a sharper angle at this place. When the "ordinary," or high, wheels came into use and racing first began, about 25 years ago, the tracks were not banked at all. The speeds were, of course, not so great as now, 3 minutes being good time for a mile. The riders had to check speed when rounding the curves; but in the heat of a race this was sometimes neglected, and many a "spill" with serious consequences resulted. The tracks ought to have been banked (and were as time progressed) although in a less degree than at present. (*b*) The position of the crank-shaft does not affect the driving power. The shaft is kept low, so as to avoid perching the rider too high up, in following a pacing machine, the lower the body of the rider, the better, as he is then better sheltered. (*c*) It is generally supposed to be due to the constantly varying refractive power of the atmosphere. The density of the atmosphere is not constant; variations of temperature may divide it into strata of varying densities, and, therefore, of varying

refractive powers. Also, the presence of warm and cold currents may divide the atmosphere into strata of varying refrangibility, owing to their being more or less charged with moisture. The effect of this constantly changing refractive power of the atmosphere (whatever the reason) is to cause the position of the star to appear to change rapidly in all directions, the apparent displacement being very minute and rapid. This gives rise to the phenomenon known as "twinkling." The effect is more noticeable in the case of stars, as compared with that of planets, owing to the minute apparent size of the former, no defined disk being discernible in their case with any telescope now in use. A minute amount of displacement due to refraction is, therefore, more noticeable in their case than in that of planets.

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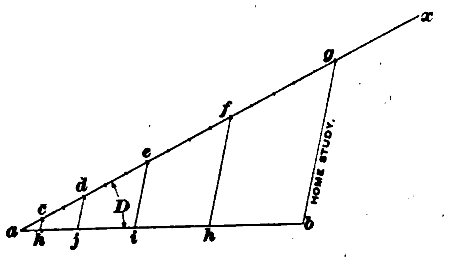
(345) Given a straight line of definite length, show how to divide it graphically into 4 parts proportional in length to the numbers 1, 2, 3, 4, and 5.
G. C. B., Pittsburg, Pa.

ANS.—Let ab be the given line; and let it be required to divide it into 5 parts proportional to 1, 2, 3, 4, and 5. Draw ax, making an acute angle D



with ab; then with the dividers lay off any small length, such as ac, on ax. Make $cd = 2ac$, $de = 3ac$, $ef = 4ac$, and $fg = 5ac$. Join gb, and draw fh, ei, dj, and ch parallel to gb. The line ab has then been divided as required.

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(346) (*a*) Will you please explain how a locomotive gets round a curve without the wheels slipping on the rails? (*b*) What is done with the wheels when they wear down so as to be the same diameter all across the face? A. M., Elkhorn, Montana.

ANS.—(*a*) An engine cannot round a curve without her wheels slipping. The inner and outer pairs have to travel unequal distances in the same period of time; it is therefore quite evident that if the inner pair *roll*, the outer ones must slide forward; and if the outer ones *roll*, the inner ones must keep slipping backward. There is also lateral sliding of both pairs. It is sought to overcome the circumferential slip by curving the wheel treads. This would be all right for *one* axle, but, where two or more are coupled together, the value of the curving is considerably lessened. The farther apart the wheels are, the less effect does the curving have. (*b*) When the tires are worn hollow, they are turned up in the lathe until the proper profile of the tire and flange is restored. All flat spots are taken out, just leaving a witness mark of the lowest spot. The main drivers are generally worn the most. Whatever size they are turned down to, however, the other drivers have to be turned to suit, whether they require it in themselves or not.

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(347) We have a steam fire engine in our town, the boiler of which acts very queerly at times. After a fire, or practice, immediately on arriving at the house, the boiler is blown out. Then after waiting for the boiler to cool it is again filled out of sight. During the next two days the water gradually falls to 2½ gauges, where it remains. What is the cause of this? About a year ago the boiler was tested and found all right, and is apparently so still.
X. Y. Z., West Newbury, Mass.

ANS.—There is evidently a leakage somewhere, and from what you say, it must be above the water line.

***

(348) (*a*) How wide is the Columbia river and how great a fall has it? (*b*) Would it be a good place for a power house and what available power would there be? (*c*) Explain the winding of a three-phase and of a two-phase generator? (*d*) What is the monophase? A. H. N., Indianapolis, Ind.

ANS.—(*a*) That depends on what portion you refer to. The mouth is in places more than 5 miles wide for a distance of about 15 miles. We do not know just what difference in height there is between the mouth and source. (*b*) There is immense power available in this river, as it is full of rapids and waterfalls and discharges an immense volume of water (see Reports of U. S. Geological and U. S. Geodetic Survey). (*c* and *d*) Only alternating currents have phases. The phase of a current is that part of the complete cycle of change through which it has gone in passing from zero to a maximum and back to zero. When we speak of two-phase currents we mean currents which are not at zero at the same time, but usually currents such that one will be a maximum when the other is zero. When speaking of three-phase currents we mean that no two of these are at zero at the same time and usually one is behind the other just ⅓ of an alternation. The monophase generator is one which has but one external circuit, or if it has more, they are in multiple, and the currents are all generated in unison, that is, they all reach maximum and minimum at the same time. The winding of a three-phase alternator may be effected in several ways. No clear idea of the winding could be given within the space allowable. We therefore refer you to "Polyphase Electric Currents," by S. P. Thompson.

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(349) Where can I get "U. S. Inspectors of Steam Vessels' Rules and Regulations," revised up to date?
F. L., Port Townsend, Wash.

ANS.—Address James A. Dumont, Supervising Inspector General, Board of Supervising Inspectors of Steam Vessels, Treasury Department, Washington, D. C.

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(350) I would like to have you explain what effect the following solution will have upon steel: One pound of "Arm and Hammer" brand baking soda, 1 pound of borax, 1 pint of hammer dust (the scales that fall around the anvil in the smith's shop), 50 gallons of water—the whole covered over with charcoal. What chemical action takes place and will the solution affect the steel in any way? I am a tool sharpener at a mine and use the solution, believing that it makes the steel harder; the drills seem to wear longer in the same rock. The water used is very soft, but cracks the hands a good deal.
R. L., Gillett, Colo.

ANS.—It is possible that a little of the carbon is taken up by the surface of the hot steel, and if such is the case it would tend to harden the surface. Many tool sharpeners use solutions similar to the one you name, with good results, but whether these results are obtained owing to a chemical or physical action has not yet been discovered.

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(351) Noting your article on "Arithmetical Progression" in the July issue, I send herewith a problem which has bothered me for some time: A man borrows \$5,000.00 which he agrees to return in 5 years with 6 per cent. interest. He further agrees to pay the interest monthly and at the same time to make a payment on the principal. He wishes the monthly installments to be equal in amount, so

that in exactly 5 years both interest and principal will have been paid. What will be the amount paid monthly, and how is it figured?

A. J. H., New York, N. Y.

ANS.—Let $p =$ the principal; $r =$ the rate for one of the equal intervals of time; $n =$ the number of payments; $x =$ one of the equal payments. By the U. S. rule for Partial Payments, the amount unpaid after the first payment is $p(1+r)-x$; after the second payment, $[p(1+r)-x](1+r)-x = p(1+r)^2 - x(1+r)-x$; after the third payment, $[p(1+r)^2 - x(1+r)-x](1+r)-x = p(1+r)^3 - x(1+r)^2 - x(1+r)-x$. Hence, after n payments, we evidently have $p(1+r)^n - x(1+r)^{n-1} - x(1+r)^{n-2} - \ldots\ldots - x(1+r)^2 - x(1+r) - x = 0$.

Therefore,

$$x = \frac{p(1+r)^n}{(1+r)^{n-1}+(1+r)^{n-2}+\ldots+(1+r)^2+(1+r)+1}$$

The denominator is a geometrical progression whose first term is 1, and common ratio $1+r$. The formula for the sum of the terms of a geometrical progression is

$$s = \frac{a(r^n-1)}{r-1};$$

n which $\quad n = n-1+1 = n.$

Substituting,

$$s = \frac{1[(1+r)^n-1]}{1+r-1} = \frac{(1+r)^n-1}{r}.$$

Substituting this value of the denominator in the equation giving the value of x,

$$x = \frac{p(1+r)^n}{\frac{(1+r)^n-1}{r}} = \frac{pr(1+r)^n}{(1+r)^n-1}.$$

In the example given, $p = \$5{,}000$; $r = .06 \div 12 = .005$, and $n = 5 \times 12 = 60$.

Hence,

$$x = \frac{pr(1+r)^n}{(1+r)^n-1} = \frac{\$5{,}000 \times .005 \times 1.005^{60}}{1.005^{60}-1} = \$96.51,$$

using five-place logarithms. By the Vermont rule, the amount of the principal and the amount of each payment is calculated to the date of settlement. The amount of the principal to date of settlement is $p(1+nr)$; the amount of the first payment is $x[1+r(n-1)]$; of the second payment, $x[1+r(n-2)]$; of the third payment, $x[1+r(n-3)]$; etc.

Hence,

$$p(1+rn) = x[1+r(n-1)] + x[1+r(n-2)] + x[1+r(n-3)] + \ldots + x\{1+r[n-(n-2)]\} + x\{1+r[n-(n-1)]\} + x\{1+r[n-(n-0)]\}.$$

Consequently,

$$x = \frac{p(1+nr)}{[1+r(n-1)]+[1+r(n-2)]+[1+r(n-3)]+\ldots+(1+2r)+(1+r)+1}.$$

The denominator is an arithmetical progression whose first term is 1 and common difference is r. The formula for the sum of the terms, when the first term, number of terms, and common difference are given, is $s = \frac{n}{2}[2a+(n-1)d]$. In the present case, $n = n-1+1 = n$, $a = 1$, and $d = r$; substituting, $s = \frac{n}{2}[2+(n-1)r]$.

Substituting in equation for x,

$$x = \frac{p(1+nr)}{\frac{n}{2}[2+(n-1)r]} = \frac{\$5{,}000(1+60\times.005)}{\frac{60}{2}[2+(60-1)r]} = \$94.408.$$

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(352) Can you tell me how to find the "telephone center" of a city? In other words how can I find the point at which to locate a central office, so that, after running a line to each subscriber, the total amount of wire will be less than if located at any other point?

A. B. F., Elmira, N. Y.

ANS.—To exactly calculate the telephone center of a city would be a stupendous undertaking. If the subscribers were evenly distributed, the center would be the geometrical center of the area covered by the service. Otherwise, the center will fall nearest to the center of that area most thickly covered.

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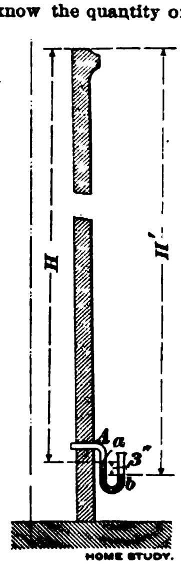
(353) (*a*) How much water must be placed in a donkey boiler before the gauge indicates, bearing in mind that the gauge is nearly at the top of the boiler? Are all boilers alike in this respect? (*b*) What is meant by the expression "the chimney gives a draft of 3 inches of water"? (*c*) How are steam gauges tested?

H. F. S., Cosmopolis, Wash.

ANS.—(*a*) Your first question is not clear. Evidently you do not desire to know the quantity of water that must be in the boiler before it shows in the gauge glass, since you would have given the boiler dimensions. If you have in mind the *height*, we can only say that the water height in the boiler should correspond with that in the glass, if the openings are clear. (*b*) When a chimney is working, the gases (from the boiler flues) ascending therein have a much higher temperature than the outer atmosphere; they are therefore correspondingly lighter. The draft set up in the chimney is due to the difference in weight of the column of heated air in the chimney and a similar column of air outside. In the annexed sketch is shown a method of measuring the draft. *A* is a bent tube, inserted in the side of the chimney, near the bottom. Water is contained inside this tube, which, it will be noticed, is necessarily much exaggerated in size compared with the chimney itself. If the entrance to the flues were to be stopped, and the temperature inside the chimney to be the same as outside of it, the water would stand at the same level in both legs of the tube. If the temperature of the gases rises, the air becomes lighter, and, therefore, the pressure on the water at *a* becomes less than at *b*; *b*, consequently, will descend and *a* rise, until the column of air *H*, together with the small column of water between the levels *a* and *b*, balance the column of air *H'*. In ordinary working, the distance between *a* and *b* will average ½ inch to 1½ inches, according to the height of chimney, temperature of the gases, etc. The draft you mention is extreme. It is very seldom that 2 inches is exceeded. The actual intensity of draft required in any particular case depends on the kind of fuel used.



(*c*) Some people use a small hydraulic hand pump provided with a valve which can be set by means of a shifting weight on its lever, to lift at any desired pressure on the square inch. The gauge to be tested is screwed onto this pump, and the weight set for the valve to lift at 100 pounds or whatever it may be. A comparison can then be made between the action of the valve and the reading of the gauge. Or, the gauge to be tested can be compared directly with a standard gauge known to be accurate, by both being simultaneously subjected to the same pressure.

(354) (*a*) I want some information on pumping water. The conditions are these: A large spring at the foot of a hill, an orchard on the hillside running up as high as 150 feet. Wood costs me nothing. The object of the pumping is irrigation. What would be the approximate horsepower required to irrigate 20 acres, allowing 600,000 gallons for one wetting and 6 to 10 days time for pumping? What would be the probable cost of engine and pump? Which would be the cheaper—gasoline or steam? (*b*) What would be the best method of pumping with these conditions: Branch running about 5,000,000 gallons per day, fall obtainable by running it around hillside for about 500 yards from 12 to 14 feet. What proportion of water would ram deliver at heights of 50 feet, 100 feet, and 150 feet? (*c*) A small wheel is desirable for grinding etc.; would it be practicable to pump with it? What is the best kind of wheel for the above stream and cost of same? (*d*) What would be the cost of a ram to irrigate about 20 acres? S. R. C., Dalton, Ga.

ANS.—(*a*) We recommend the use of a direct-acting steam pump as the cheapest, simplest, and most certain device for irrigating your orchard. In regard to the size of pump and its cost, we advise you to write to a number of pump makers, giving them a complete description of the location and the service required and ask them to submit plans and estimates for the work. (*b*) We do not know of a ram of sufficient size to do the work you require. (*c*) Under the conditions you give, the stream may be made to develop from 5 to 8 horsepower with a good turbine wheel for 24 hours per day. If you can build a reservoir to hold the water during the night, so as to make it possible to use it all during a period of 10 hours instead of having the flow distributed over the whole 24 hours, the stream might be made to develop from 12 to 18 horsepower. This would probably furnish the water for irrigation at the rate you require and might be economical provided you have sufficient other work to keep the wheel running during a considerable part of the year. It is probable, however, that the interest on the cost of the wheel, flume, dams, etc., together with the cost of keeping them in repair, would make the expense of irrigating your orchard much greater than by the use of a steam pump. A careful study of all the conditions by an expert on the ground would be necessary for a correct estimate of the cost of this method of pumping.

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(355) I want to make a battery motor that will run a good-sized fan. Please give me the necessary instructions. J. B., Fredericksburg, Pa.

ANS.—It will require about $\frac{1}{8}$ horsepower. Using ten bichromate-of-potash cells in series you will require about 7 amperes current. We could not give you all the directions required in the limits of our space. It would be cheaper to buy such an outfit. Write to the Gordon Battery Co., 594 Broadway, New York, or Edison Manufacturing Co., St. James Building, New York.

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(356) Please explain the wiring of an American Bell telephone instrument. O. S., Montclair, N. Y.

ANS.—Examine Prescott's "Bell's Electric Speaking Telephone; Its Invention, Construction, Application, Modification, Etc." 785 pages, 516 illustrations, price, \$4.00. For sale by The Technical Supply Co., Scranton, Pa.

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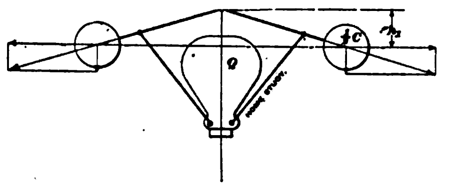
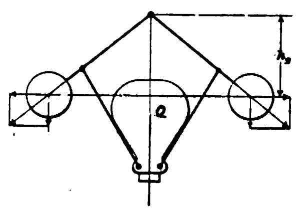
(357) In answer to Question 185 in the May number of HOME STUDY MAGAZINE, you are all right until you get to the last part where you say, "If, now, the engine runs too fast, adjust the governor rod so as to make the cams trip their latches earlier in the stroke," etc. You have never tried to do this, or you would not have written it. It is just as impossible to change the speed of a Corliss engine through manipulations of the governor rods as it is to lift yourself over a stone wall by your boot straps—always supposing the engine has a constant load. Shorten the rod as you speak of doing, and the governor promptly falls enough to compensate what has been done, and vice versa. H. E. F., Ware, Mass.

ANS.—Our answer to Question 185 was correct. The governor of a Corliss engine is nearly always either an ordinary Watt governor or a Porter-Allen governor. These governors are not close regulators within a large range, as, when running with their balls on a higher level, they necessarily revolve perceptibly faster than when running with their balls on a lower level. The relation existing between the number N of revolutions per minute of the governor for any portion of the balls, and the distance h in inches of the centers of the balls below the point of intersection of their arms corresponding to that position, may be expressed by the formula

$$N = \frac{187.6}{\sqrt{h}}\sqrt{1 + \frac{Q}{C}},$$

in which Q is the weight of the center sleeve, and C is the weight of the two balls. In view of this fact, we surely made no misstatement in our answer to the question referred to, though it was, no doubt, a





mistake on our part not to state that we had reference to only slight variations in the speed of the engine. Taking the two extreme heights h_1 and h_2, corresponding to the extreme revolutions N_1 and N_2, we have

$$N_1 = \frac{187.6}{\sqrt{h_1}}\sqrt{1 + \frac{Q}{C}}, \text{ and } N_2 = \frac{187.6}{\sqrt{h_2}}\sqrt{1 + \frac{Q}{C}},$$

and accordingly $$\frac{N_1}{N_2} = \sqrt{\frac{h_2}{h_1}}.$$

If this h for a particular engine varies between $h_2 = 12$, and $h_1 = 10$,

$$\frac{N_1}{N_2} = \sqrt{\frac{12}{10}} = 1.095445.$$

That is to say, the variation in speed would be nearly 10 per cent.

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(358) In the deepest sea, is the water compressed to such an extent that iron or steel is prevented from sinking in it? In other words, will a heavy metal go to the bottom however deep the sea may be?
N. H. M., Boca, Colo.

ANS.—Water is compressed slightly under the great pressures to which it is subjected at the depth of a mile or so. A cubic foot of sea-water at the surface weighs about 64.1 pounds and at the depth of a mile

it weighs 64.5 pounds. As iron is less compressible than water, its density will increase less rapidly than that of water when pressure is applied. As a consequence it will sink until the water becomes denser than the iron. This depth will be very great—many times greater than any possible depth of the ocean.

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(359) Please inform me if what is known as the Cuttriss telephone transmitter is patented in this country. The electrode, or variable resistance, consists of a small spiral carbon spring.

P. P. E., Coshocton, Ohio.

ANS.—Yes. You can obtain a copy of the patent by applying to the Patent Office, at Washington, D. C.

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(360) Will you kindly give a list of books that might form the nucleus for a modest library to help the young mechanics in a machine shop? It is fairly easy to make a choice of books that will help boys over their difficulties, but not so easy to pick out books that will be of assistance to the mechanic—books that give the names of machine parts, instructions on so called every-day jobs, etc.

C. H. S., Hampton, Va.

ANS.—As you say, it is not an easy matter to select the books you desire. Such books are usually quite expensive. The following list will probably be of value to you. If the books are for a private library, some of them could be omitted on the score of expense; otherwise, if "the modest library" is intended to be used by a number of people who have combined together to purchase certain books that are to be mutually beneficial to them, it would be well to purchase them all. Knight's "Mechanical Dictionary"; Appleton's "Dictionary of Applied Mechanics," and Appleton's "Modern Mechanism"; "Modern Machine Shop Practice," by Joshua Rose; "The Modern Machinist," by Usher; "The Pattern-Maker's Assistant," by Rose; "Power Catechism," "Catechism of the Locomotive," by Forney; "American Steam Engineer," by Edwards; "Shop Kinks," by Grimshaw; "A Treatise on Steam Boilers," by Wilson, "Construction of Pump Details," by Bjorling; Roper's "Series of Hand-Books"; "Mechanics' Pocket Memoranda"; "The Standard Dictionary." The above named books, all of which can be obtained from The Technical Supply Company, Scranton, Pa., will make a very good beginning, and the list can be extended afterwards, as occasion may arise.

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(361) (*a*) What causes the wagon, shown in Fig. 1, to move in the direction of the arrow? (*b*) How is the principle applied to turbines? (*c*) Explain the mechanism of the wheels used in the 5,000-horsepower turbines at Niagara Falls.

FIG. 1.

V. S., Canton, Ohio.

ANS.—(*a*) The motion of the wagon is due to the *reaction* of the jet of water that issues from the nozzle. One of the laws of motion says that *every action is opposed by an equal and opposite reaction*; the pressure of the water in the tank acts to force a jet out of the nozzle, and, in accordance with the law, the reaction of the jet produces a pressure on the water in the tank that acts to push the wagon in the opposite direction. (*b*) The reaction effect of a jet flowing from a nozzle, as in the case of the tank on the wagon, is but little used in a turbine. It has been used to a slight degree in what is known as a *Barker's mill*, a familiar example of which is the rotary-head lawn sprinkler. Such an arrangement, however, is an inefficient device for utilizing the energy of falling water, owing to the fact that the water that issues from the moving nozzle must always have a comparatively high absolute velocity, which means that a large part of its energy has not been used by the motor. (*c*) There are two distinct types of turbines, which are known as the *impulse turbine* and the *reaction turbine*. In the impulse turbine the water flows from a series of openings, or guides, with a high velocity, and strikes against the curved vanes of a

FIG. 2.

wheel in such a way that the water as it passes over the moving vanes loses its absolute velocity and gives up its energy; the action is much the same as the action of a jet on the cups of a Pelton wheel, described in HOME STUDY MAGAZINE, May, 1898, article entitled "The Impulse Waterwheel." The 5,000-horsepower turbines at Niagara Falls are of the reaction type. In their general form, the reaction and impulse types are very similar, the chief difference being in the manner in which the water acts. Fig. 2 is a diagram showing the general arrangement of the guides and wheel vanes of an outward-flow turbine, to which class the Niagara Falls turbines belong. The water is brought into the spaces between the guide vanes *B, B*, through a penstock leading from the supply canal. It flows outward through the spaces between the guides and into the spaces between the wheel vanes *C, C*. The direction of motion of the water is thus changed, and this change in direction produces a pressure on the wheel vanes that causes them to turn. In the reaction turbine, in addition to the pressure due to the change in direction of motion, there is a certain amount of pressure exerted on the wheel vanes by the hydrostatic head of the water, and in some cases there is a slight effect due to the reaction of the water as it leaves the vanes; the reaction of the issuing jet, however, is generally very small in a well designed wheel running at the proper speed. The peculiarities of the Niagara Falls turbines, which distinguish them from the ordinary outward-flow turbines, are their unusual size, the high pressure under which they work, the arrangement of the wheels for balancing this heavy pressure, and the arrangement of the gates for controlling the flow of the water.

(362) In HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., August 1897, there was an article that interested me very much, entitled "Making Ice by Boiling Water." Kindly now, give me your opinion as to the most modern and best way of making ice; also tell me where I can obtain all particulars as to cost of putting up an ice plant.

J. W. C., Weldon, N. C.

ANS.—The most modern method of making ice is by the ammonia process. In this process, anhydrous (dry) ammonia is compressed by means of a powerful pump into the form of a liquid. This liquid ammonia on being suddenly expanded draws heat from surrounding bodies lowering their temperature. In those processes where brine is used to freeze water into ice, the brine is first cooled by the expanding ammonia and the cold brine is then circulated about the freezing tanks. You may obtain all the particulars of cost, etc., by writing to the following companies; The Frick Co., Waynesboro, Pa.; The Westinghouse Machine Co., Pittsburg, Pa.; The Remington Ice Machine Co., Wilmington, Del.; The De La Vergne Refrigerating Machine Co., foot of East 138th Street, New York, N. Y.

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(363) Kindly inform me how to wind a magnet for a telegraph instrument and what size wire to use?

R. B., Hensall, Ont.

ANS.—For ordinary relays use No. 36 silk-covered wire. The size of magnets will depend on circumstances. You can see such instruments in any telegraph office. The magnets are usually from 2 to 3 inches long and about ½ inch in diameter, and are wound to a depth of about ⅜ of an inch, just as a spool of thread is wound.

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(364) (*a*) Kindly give me directions for putting up an electric call bell; the bell and battery to be in the same house. (*b*) Can I use the same battery that is used for the door bell?

C. P. G., Lansdale, Pa.

ANS.—(*a*) The bell may be installed in precisely the same way as the door bell. Run one wire from one pole of battery to one terminal of bell and connect the other terminal of bell to other pole of battery. Insert a push button in the circuit, so that when the button is pressed the circuit will be closed and the bell will ring. Use about No. 18 insulated copper wire for short distances. Call bells which are to be operated at great distances, say a mile or more, will require a magneto generator, that is, a little dynamo with permanent steel magnets, generating an alternating current. Such instruments are used on telephone lines. (*b*) You can use the same battery.

***

(365) Will you please give me a rule showing how to figure out the length of board, 1 foot wide with ends cut square, that can be laid on the floor of a room 16 feet by 24 feet? I would prefer it figured out in arithmetic if possible.

P. W., Lake Linden, Mich.

ANS.—See HOME STUDY MAGAZINE, May, 1897, Answers to Inquiries, No. 140.

***

(366) I have come across the following formulas for the determination of the horsepower required to haul railroad cars: On a level, H. P. $= \frac{w \times k \times s}{375}$ (1); on a grade, H. P. $= \frac{w s}{375}$ $(k \pm 2{,}000 \sin a)$ (2), which approximately equals $\frac{3 w s + (2 s \times p)}{37.5}$ (3). In these formulas s = speed in miles per hour; w = load hauled, in tons of 2,000 pounds; k = constant, assumed to be 30 pounds per ton; a = angle of elevation; p = percentage of grade. I do not understand these formulas. A clean-cut formula from you will fix the whole affair.

I. S., San Francisco, Cal.

ANS.—We have not seen the above formulas, but they were evidently obtained as follows:

$$\text{Horsepower} = \frac{\text{force exerted (lb.)} \times \text{distance traversed (ft. per min.)}}{33{,}000}$$

In the present case,

$$\text{H. P.} = (w \times k) \times \frac{5{,}280\, s}{60} \div 33{,}000 = \frac{w k s \times 88}{33{,}000} = \frac{w k s}{375}. \quad (1)$$

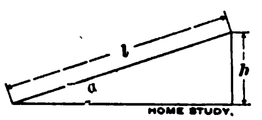
On an up grade, work has also to be done in overcoming the resistance due to gravity, that is, work is done in lifting the train vertically. If we denote the pitch of the slope by R (the pitch is the ratio of the height of the slope to its length, $\frac{h}{l}$ in figure), the resistance of the train, in pounds, due to gravity = $2{,}000\, w \times r$, and H. P. =

$$2{,}000\, w\, r \times \frac{5{,}280\, s}{60} \div 33{,}000 = \frac{2{,}000\, w\, r\, s}{375}.$$

The total horsepower, therefore, =

$$\frac{w k s}{375} \pm \frac{2{,}000\, w\, r\, s}{375} = \frac{w s}{375}(k \pm 2{,}000\, r) = \frac{w s}{375}(k \pm 2{,}000 \sin a), \quad (2)$$

since $r = \sin a$. We write $\pm$ so as to include the case of the train being on a down grade, in which event gravity acts *with* the tractive effort of the engine, instead of against it. The net effort required is then the difference of the two amounts $\frac{w k s}{375}$ and $\frac{2{,}000\, w\, r\, s}{375}$. Substituting 30 for k in formula (2), we get the total horsepower =



$$\frac{w s\,(3 \pm 200 \sin a)}{37.5}. \quad (a)$$

The formula (3) given in the question is evidently incorrectly stated. If in (a), just obtained, we substitute $\frac{p}{100}$ for $\sin a$, p being the rate per cent. of the grade, we obtain

$$\text{H. P.} = w s \frac{\left(3 \pm 200 \times \frac{p}{100}\right)}{37.5} = \frac{w s (3 \pm 2 p)}{37.5} = \frac{3 w s \pm 2 w s p}{37.5} \quad (3)$$

***

(367) In HOME STUDY MAGAZINE, May, 1898, Answers to Inquiries No. 160, does 2.5 in $\frac{72{,}106.3}{142 \times 2.5}$ come from the second table? If so, how is it derived?

M. A. G., Port Henry, N. Y.

ANS.—Yes. It is taken from the right-hand column of the second table. You will notice that 2.48 B. T. U. are given in this column for a difference of 140° F. between the temperature of the radiating surfaces and the air, which for a difference in temperature of 142° F., would give us about 2.5. This 2.5 refers to the average number of British thermal units of heat which each square foot of radiating surface will transmit to the air of the room for each degree difference between the temperature of the steam and the air in the room.

***

(368) We are having serious trouble with the cylinder of our engine. It is cutting badly at each end right at the steam port and nearly parallel from end to end of the cylinder, which is 20 inches in diameter and 26 inches stroke, the steam pressure at

boiler is 200 pounds. The enclosed sketch, Fig. 1, will help you to understand the trouble. The piston head is solid, with no bull ring or follower: the rings, which are parallel and sprung over the piston, are 5¼″ × 1¼″; there is a spring balance at the bottom to keep the piston central, but it is not strong enough to do any harm. The engine has top and bottom guide bars, which are perfectly in line with the bore of the cylinder. I must not forget to mention that the cylinder gets plenty of oil; we use a Detroit lubricator. Can you explain the cause of the trouble?

S. O. E., North Port Huron, Mich.

ANS.—The experience you relate is rather an unusual one, we imagine. We can think of no

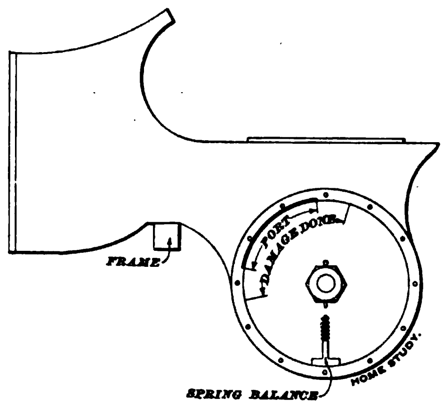


FIG. 1.

explanation other than that the core must have shifted and left the wall weak under the steam passage. Then, at the beginning of the stroke, the incoming steam (and you carry a high pressure, too) being momentarily "held up" by the piston, closes in the cylinder wall, owing to the weakness above mentioned: this part of the cylinder, therefore, bears hard on the piston, with the result of increased wear at this point. We suggest that you caliper the wall at a, Fig. 2. It ought to be at least 1¼ inches. It is not quite clear to us whether or not you intend to convey that this excess wear extends the whole length of the cylinder. It is clearly not a matter of lubrication. If that were deficient, the cutting would not be localized in this manner: in fact, we should, in that case, look for increased wear to be where the greatest wear *ordinarily* occurs, namely, on the *other* side of the cylinder—*opposite* the ports.

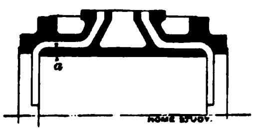


FIG. 2.

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(369) (*a*) How did Pouillet measure the amount of light given out by the sun? (*b*) Define atomic heat, and explain how it is used to verify the atomic weight of a metal. (*c*) It is found that 32½ parts of *Zn* will combine with 35½ parts of *Cl*; the specific heat of *Zn* is .095; find its weight. (*d*) In 60 grams of $Fe_2SO_47H_2O$, find the weight of *Fe*. (*e*) Why is NH_4 referred to as though it were a metal?

J. A. V., New York City, N. Y.

ANS.—(*a*) See HOME STUDY MAGAZINE, January, 1897, page 280, for apparatus used by Pouillet in lecture by Professor Gerald Molloy on "The Sun." (*b*) Dulong and Petit discovered the fact that the product of the specific heat by the atomic weight is constant for nearly all elements; or, what is the same thing, the specific heat of an element is inversely proportional to its atomic weight. This constant product is called *atomic heat*, and since it has the same value for nearly all elements, it follows that the atomic heat of all atoms is the same. Since the average value of this product is 6.4, it is evident the atomic weight of an element is approximately obtained by dividing 6.4 by the specific heat. (*c*) $6.4 \div .095 = 67.36$ approximately, the atomic weight of zinc. More accurately, it is $6.230 \div .09555 = 65.2$, which result seems to contradict the given proportion; taking, however, into consideration, the fact that zinc is a dyad and that it consequently needs 2 atoms of *Cl* to form a saturated compound with it, the true proportion must be 1 atom *Zn* to 2 atoms *Cl*, and as the atomic weight of chlorine is 35.5 it follows that the true molecular proportion must be 65 parts (1 atom) *Zn* to 71 parts (2 atoms) of *Cl*. (*d*) We do not know of such a compound; there is an $FeSO_47H_2O$. However, the following information is what you request us to give you: The molecular weight of $Fe_2SO_47H_2O$ (supposing such a substance to exist) is

$$
\begin{aligned}
Fe_2 &= 112 \\
S &= 32 \\
O_4 &= 64 \\
7\,H_2O &= 126 \\
\hline
& \ 334
\end{aligned}
$$

or, in 334 grams of $Fe_2SO_47H_2O$ are contained 112 grams of *Fe*; in 60 grams of the compound there must be 20.1 grams of *Fe*. (*e*) The group NH_4 is treated as a metal because salts are formed by it.

***

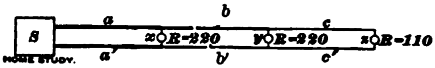
(360) In the accompanying sketch, what should be the resistance at a and a', b and b', c and c', in order to obtain a drop of 10 per cent.? Explain how it is obtained.

J. C. H., Montgomery, Ala.

ANS.—The size of the conductors of any electric system is calculated from Ohm's law,

$$C\ (\text{amperes}) = \frac{E\ (\text{volts})}{R\ (\text{ohms})},$$

or from a modification of the same. It is, therefore, quite apparent that, in the above problem, two vital factors have been omitted, viz., the current in amperes, and the pressure in volts. The question thus takes no definite shape. In actual practice, the following quantities are either actually known or else assumed: the greatest allowable drop, measured in volts; the distance to each lamp, from which the distance to the center of distribution is calculated; and the current consumed by the various electrical devices. For the purpose of illustration, let us assume that we wish to wire two 16-candlepower lamps x and y, and one 32-candlepower lamp z, situated 50, 100, and 150 feet, respectively, from the



source of supply S, which furnishes current at 112 volts pressure. In this case, 10 per cent. of 112 volts is over 11 volts drop, or variation in electric pressure, which is too large to be permissible; we will, therefore, take 2 volts as allowable. In solving this problem, we know that a 16-candlepower lamp consumes practically ½ ampere, and a 32-candlepower lamp 1 ampere. The first thing to calculate is the distance from S to the center of average distance. The lamp z is equivalent to two 16-candlepower lamps. The average distance is, therefore,

$$[50 + 100 + (150 \times 2)] \div 4\ (\text{lamps}) = 112.5 \text{ feet.}$$

All the factors are now available for the following formula. Size of wire, in circular mils, = (10.8 × electrical distance, in feet, × current, in amperes, ÷ drop, in volts,) = $[10.8 \times (111.5 \times 2) \times 2] \div 2 = 2{,}430$

circular mils; the nearest size wire is No. 16 of 2,583 circular mils, and, as it will safely carry 2 amperes, it is the proper wire to use. As calculated, the voltage at z is nearly 2 volts less than at S, while at y and x the variation is not so great. It may be mentioned that the "electrical distance" is twice the linear distance, because the current goes and returns, that is, covers the actual distance twice.

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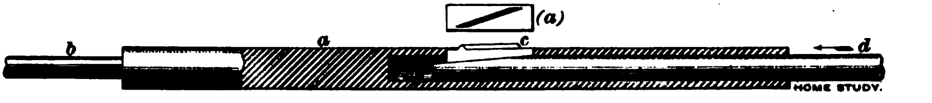
(371) (*a*) Can lantern and lamp chimneys be made to withstand the heat of a strong blaze? If so, how is it done, and what is the particular kind of glass used? (*b*) How are the grooves cut in rifle barrels, and what makes some makes of rifles more accurate shooters than others? (*c*) How can two pieces of iron or steel be securely soldered? (*d*) Can good glue be distinguished from an inferior qualty without first wetting it? J. C. H., Wishart.

ANS.—(*a*) No; a chimney made of mica will probably answer the purpose. (*b*) In what is considered to be the best modern practice, the grooves in a rifle barrel are cut by means of the tool shown in the accompanying figure. The body *a* of the tool is rigidly fastened to the rifle rod *b*. The body is mortised to receive the rifle-saw *c*, a plan view of the saw being shown at (*a*). In operation, the body of the tool, which is made to fit the barrel about to be rifled, is alternately pulled and pushed through the barrel; suitable mechanism for giving it a spiral motion being provided. The rifle saw will make a faint cut at each passage through the barrel, the removal of metal being more of a scraping than a cutting operation. After the saw has passed back and forth through the barrel, the latter is revolved an angular distance, depending upon the number of grooves to be cut. The barrel having made a complete turn, so as to bring the rifle saw back to the first groove cut, the saw is forced outward a little by driving the cylindrical pin *d*, the front part of which forms a wedge, a small amount in the direction of the arrow. In automatic rifle machines this operation is performed by the machine itself. The operation is repeated after each revolution of the barrel until the grooves are of the desired depth. The rifle saw is supplied with plenty of oil at each passage through the barrel. In reply to your question as to why one make of rifle barrel is a more accurate shooter than another make, the writer is forced to assert that such a state of affairs does not exist; basing his conclusions upon his own tests made upon rifle barrels of nearly all manufacturers of firearms in the United States. The writer has invariably found that barrels made by any reputable concern are, when leaving the factory, as near perfection as human skill can make them. If one certain make of a barrel happens to give better results in a test than another one, it simply shows that the ammunition used was not as near perfection as it might have been. The writer, a short time ago, took a rifle barrel condemned by its owner, and, by proper manipulation of the ammunition, made it shoot a wonderful ten-shot group, thus proving to the owner that the particular make of barrel was accurate, and that it appeared inaccurate simply because he did not use the right ammunition. (*c*) Braze them together as follows: Thoroughly file and clean the surfaces to be soldered. Spread a thick paste of borax over the cleaned surfaces, and tie the parts together temporarily with iron wire to keep them from shifting. Lay some spelter, i. e., hard solder, over the seam. Apply heat either with a charcoal forge or an air-and-gas blowpipe until the spelter melts, and sweats into the seam; then remove the heat. Do not disturb the work until it has cooled off. For steel, the spelter is composed of brass, 3 parts; copper, 1¼ parts; silver, 28¾ parts; for iron, 58 parts copper and 42 parts zinc. (*d*) Good glue is clear; an inferior glue is muddy and opaque.



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(372) (*a*) What is the correct method for drawing the tools shown on the enclosed blueprint? (*b*) Where can I obtain catalogues of water motors? R. K., Jersey City, N. J.

ANS.—(*a*) Since you do not state the purpose of the drawing we can only say that the blueprint seems to be correct for any ordinary use. Every maker of these tools has his own particular design and layout for the cutting edges. (*b*) The Pelton Waterwheel Co., 143 Liberty street, New York; James Leffel & Co., Springfield, Ohio; The Backus Water Motor Co., Newark, N. J.; American Impulse Wheel Co., 120 Liberty street, New York.

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(373) We have in the house 18 pendant and 4 automatic gas lighters, each insulated from the gas pipe and supplied with return wire. The power for the spark comes from 5 ordinary carbon batteries with a spark coil attached. Everything has worked well until recently. For two or three weeks, at about noon each day, the line has become short-circuited and remains so until about 9 P. M., when it opens again. During the hours that the line is short circuited, I have the line disconnected from one end of the battery, except when I am testing it to see if it is open. The spark given off at the batteries by making and breaking the circuit is as big as the spark given off by the lighters. Have you ever heard of a parallel case? What do you suppose is the cause? D. M., Brighton, Mass.

ANS.—The only thing that can be definitely stated is that you certainly have a "dead" short circuit during the hours named. The possible causes are very numerous. Perhaps the trouble comes from moisture. We know of a parallel case; it was a wire "bridge" placed across two of the wires by a practical joker. The only way to discover the cause is by careful testing, say with a buzzer and a small battery.

***

(374) What size solenoid is required to raise 50 pounds 2 inches? Give the diameter of bore, length, size, and amount of wire for a 500-volt circuit. W. J. F., Pittsburg, Pa.

ANS.—Diameter of bore, 1.6 inches; length 40 inches. Using No. 20, B. & S. guage wire, it will require about 10,000 feet to get sufficient resistance for a 500-volt circuit.

***

(375) I am running a Leonard-Ball Automatic Engine. I find that it is necessary to fill the dashpot of the governor twice a week with good engine oil. What I want to know is, what becomes of the oil? Where does it go? The pot is filled from the top; the oil holes are plugged with small machine screws; the pot is a solid brass casting; and the rod is packed with Garlock ring packing with screw gland. I don't see how the oil can get out around the rod, because it seems to me that centrifugal force will prevent this; then, again, there are no signs of oil on the plunger rod. Can you explain the rapid disappearance of so much oil? A. W. C., Lorne, Ont.

ANS.—The oil probably gets by the piston, and is

taken out by the air as it discharges through the valve. This could easily happen and not be noticeable.

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(376) (*a*) What is the correct layout for the transition piece shown at *A* and *B*, Fig. 1? (*b*) Fig. 2, *B*, is a half elevation of a circular dome. It is to be made of 20 sheets, [illegible] inch thick. What is the best way to make the layout of one of the sheets?

M. B., Pittsburg, Pa.

ANS.—(*a*) To find the layout of the transition piece from round to flat with semicircular ends, draw a plan *A*, Fig. 1, and an elevation *B*. Project the center *i* into the elevation to *k*, and also project *k* into the outline in the plan *A*. By also projecting the other center *i′* in the same manner, and drawing *h k* and *h k′*, *B*, we get the triangle *h k′ k*. This triangle is a flat surface. The remaining surfaces at each end are parts of a scalene cone, and must be developed by triangulation when the apex is inconveniently far away, as it is in this case. In plan *A* this apex is *n*, but in the elevation it is where *k h* and *c g* would meet. Divide the quadrants *h g* and *k c*, *A*, each into the same number of equal parts. Any convenient number of parts will do, but there should be at least three in a small piece. As triangulation is an approximate method, depending upon the greatness of the number of triangles, the more parts used the better; but the parts should not be made too small. Draw dotted lines from *1* to *I*, *2* to *II*, etc., and full lines from *1* to *k*, *2* to *I*, etc. Where convenient, draw *2-II*, *E*, and draw *m l* perpendicular to it. To find the actual lengths of the lines *h d*, *1-k*, *1-I*, etc., *A*, draw full views of right-angled triangles, one of whose sides is one of the lines wanted. Thus, the length of *h d*, *A*, is found by making *m d*, *E*, = *h d*, *A*; and *m l*, *E*, = *h d*, *B*. Now, *d l*, *E*, is the actual length of *h d*, *A* or *B*. The length of *1-k* is found in a similar manner by making *m k*, *E*, = *1-k*, *A*. The points *k*, *I*, *II*, etc., *A*, are just as far above *e g* as *h*: so *m l*, *E*, is the common height of all these points above *m*, *E*. Where convenient for the development, draw the center line *h d*, *L*, and make it = *d l*, *E*. Draw *d k*, *L*, perpendicular to *d h*, *L*, and make *d k*, *L*, = *d k*, *B* or *A*. Now, construct the triangle *h k 1*, *L*, by making *h-1*, *L*, = *h-1*, *A*, and *k-1*, *L*, = *k l*, *E*. Then add the triangle *k-1-I*, *L*, by making *k-I*, *L*, = *k-1*, *A*; *m-1*, *E*, = *1-I*, *A*; and *1-I*, *L*, = *1-l*, *E*. The remaining triangles are added in a similar manner. The layout is completed by drawing curves through the points *k*, *I*, *II*, etc., and *h*, *1*, *2*, etc. The figure *h d c g*, *L*, is one-quarter of the required layout. (*b*) The layout of one-twentieth of the dome, Fig. 2, is found in the following manner: Draw the elevation *B* (or one-half of it, as shown) and the plan *A*. The plan is drawn under the elevation, using *d c* as a center line for convenience. Make *e′ c* and *c e* each equal to $\frac{1}{40}$ of the circumference of a circle with radius *d c*, so that *e′ e* will be $\frac{1}{20}$th, and *d c* its center line. This $\frac{1}{40}$th is found by dividing the quadrant *c c* into five equal parts, and then dividing one-fifth in half, as shown. Do the same with the edge of the hole *a b* by drawing *e d* and *e′ d* intersecting the quadrant *b b′* in *f* and *f′*. Divide the outline *b c*, *B*, into a convenient number of parts, not less than four, and the more the better within reason, in *1*, *2*, etc. Project these points of division on to the base line *d c*, *B*, to *1′*, *2′*, *3′*, etc. With center *d*, describe quadrants from *1′*, *2′*, etc., to *d c*, *A*, intersecting *e f* in *1″*, *2″*, etc. Where convenient for the layout, draw the center line *b c*, *L*, and make it equal to the length of the arc *c b*, *B*. Divide *c b*, *L*, into the same number of parts as *c b*, *B*, in *1*, *2*, etc., *L*. Draw tangents to the arc *c b*, *B*, at its ends *c* and *b*, and at each point of division, *1*, *2*, etc., intersecting the center line in *b″*, *3″*, *2″*, etc. In case it is inconvenient to continue any of these tangents to meet the center line, divide the horizontal distance of the point from the center line in half (or if necessary less) and draw a line through the point so found, parallel to the tangent. The distance of the intersection of this parallel with the center line from a horizontal line through the point is then in proportion to the reduced base. Thus, *d c*, *B*, was bisected in *g*, and *g c″* drawn parallel to the tangent

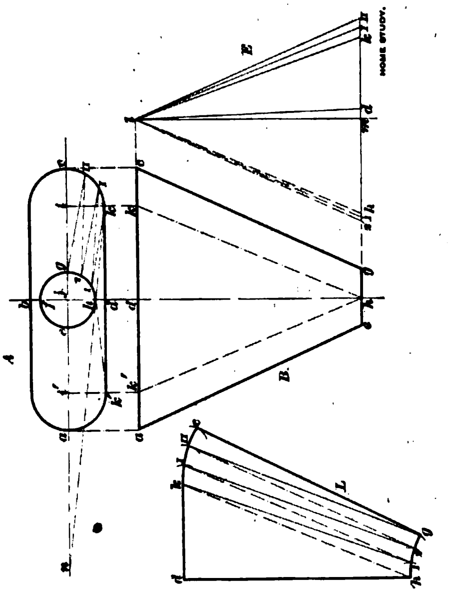

FIG. 1.

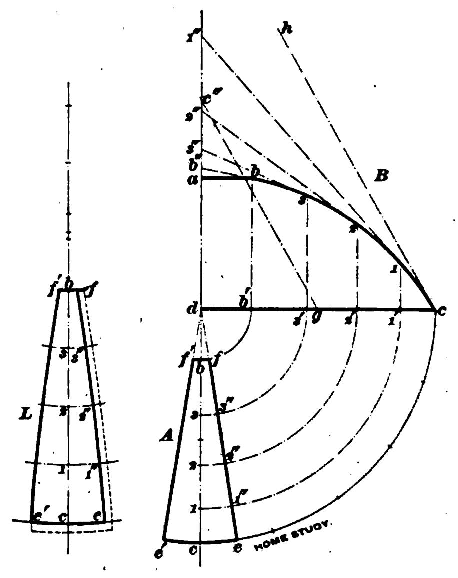

FIG. 2.

c h. The intersection of *c h* with *d a* will be twice the distance *d c''*, from *d*. With a radius equal to *b'' b*, *B*, describe the arc *f' f*, *L*. Describe the arc *3-3''*, *L*, with a radius = *3-3''*, *B*, etc., using a radius = $g c \times 2$ for the arc *e' e*, *L*. Now, make the length of the arc *c e*, *L*, = the length of *c e*, *A*; *1-1''*, *L*, = *1-1''*, *A*, etc. draw the curve *e-1''-2''*, etc., *f*, and the same on the other side, *e' f,' L*. This completes the net layout. The allowances for lap joints must be made where wanted. Allowances for stretching in hammering, etc. must also be made, in accordance with experience, to suit the method of working. The center line *b c*, *L*, should not be curved, unless it is expected that one edge will stretch more than the other in forming, punching, or riveting. The given thickness [illegible] inch is so small in proportion to the diameter of 21 feet that it will hardly change the layout of this small section.

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(377) If the lengths of two of the sides of a right-angled triangle are given, how can the number of degrees in one of the acute angles be found mathematically? What I want is a *simple* mathematical process in which the use of algebra and trigonometrical tables is avoided. A. L. G., Bangor, Me.

ANS.—There is no known method of finding the angles from the sides without the use of trigonometrical tables. The tables themselves are calculated by assuming that the length of the arc of a very small angle, say a 1-minute angle, and the length of the sine of that angle are equal, and then computing the other angles in succession, minute by minute, by making use of the values last obtained.

***

(378) What is the best kind and size of engine and boiler to propel a round-bottom steamboat, 40 feet long and 9 feet beam, which draws not more than 3 feet 6 inches of water? I want to carry freight and to do light towing. W. T. J., Dutton, Fla.

ANS.—The Marine Iron Works, Clybourn and Southport Ave., Chicago, Ill., make an outfit very suitable for a boat of the given dimensions. It consists of a $5'' \times 7''$ engine, cutting off at [illegible] stroke, and running 300 revolutions per minute. The boiler is of the submerged-tube type, internally fired, 36 inches in diameter by 58 inches long. It contains 66 tubes, 26 inches in length and 2 inches in diameter. Firebox, $25'' \times 30''$; steam pressure, 165 pounds. This boiler will burn either wood or soft coal. The outfit includes a 4-bladed propeller wheel 34 inches in diameter, and all accessories for the engine and boiler. The outfit complete weighs about 3,000 pounds.

***

(379) A wooden pipe, 3 inches inside diameter, and ¾ mile long, has a 14-foot fall and no increase of size at inlet. Is it practicable to make use of it as the drive pipe to a ram to raise water to a height of 30 feet above the ram? I say no, and see no better way than to raise the water to its own level in a tank and run a short drive pipe from this tank to the ram. Is there a better way? F. F. P., Loyalton, Cal.

ANS.—It would not be practicable to use the pipe as a drive pipe for a ram. Your plan of using the long pipe to supply a tank from which a short drive pipe is run to the ram, is probably the best system that could be used.

***

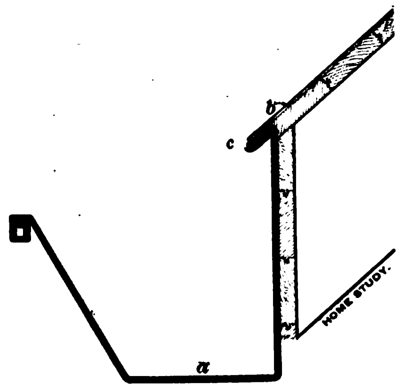
(380) I am building a granary and wish some information regarding the floor. If I build up a foot or two of solid masonry and cover it with cement such as is used for sidewalks, will I have a satisfactory floor? R. L., Ellendale, N. Y.

ANS.—A cement floor is an excellent preventative against the transmission of dampness, but it may be laid directly on the ground without building up any masonry. If coated with a layer of asphalt, it is almost perfectly damp proof, but we would advise in any case that a wood floor be laid over the cement by first setting a series of chestnut sleepers in the cement finish, then covering over these with a board floor. A circulation of air is thus maintained under the floor at all times and the grain is not so likely to become heated.

***

(381) I enclose a sketch showing connection between a copper gutter *a* and a tin roof *b* on a building. I claim that these two metals coming in contact at *c*, as shown, will cause galvanic action, and that, in consequence, the joint will in time be entirely eaten away. Is my theory correct? If it is, what method of connecting these two metals would you suggest so as to make a tight joint? W. T. H., Brooklyn, N. Y.

ANS.—Galvanic action certainly will take place between the two metals as you suggest, and the tin, i. e., iron coated with tin, will rapidly decompose all along the seam. The rapidity of the decomposition,



or *corrosion*, as it is commonly called, will depend considerably upon the closeness of the contact of the two metals, and the quantity and composition of the water which may get between them. Owing to the fact that the seam is made in the form of a drip, it would appear that no water could find its way in between the metals, but it is nevertheless a fact that some moisture will get in at times. If the seam were so constructed that water could enter it—by capillary attraction, for instance—there would be considerably more danger of galvanic action. In any case, however, it is advisable to work in an insulation strip between the two metals which will keep them apart and prevent a galvanic effect. Probably the best material to use for this purpose is thin sheet gutta percha. This would make a perfect insulator. It is common practice, however, to use tarpaulin or burlap well soaked in asphalt, and we believe that good results are obtained by this treatment.

***

(382) (*a*) What size and how many turns of wire would the armature have to be wound with for a 2-horsepower, 500-volt, series-wound, multipolar motor? (*b*) What size, etc., if 4-pole magnets were used? G., Schenectady, N. Y.

ANS.—(*a*) This involves practically the design of the entire motor. Assuming an efficiency of 80 per cent., then $\frac{2 \times 746}{.80} = 1{,}865$ watts will be required, or approximately 3.75 amperes at 500 volts.

$$\text{Torque (in ft.-lb.)} = \frac{33{,}000 \times \text{horsepower}}{2\pi \times \text{revolutions per minute}}.$$

Assuming 1,200 revolutions per minute, we have

$$\text{Torque} = \frac{33{,}000 \times 2}{2\pi \times 1{,}200} = 8.75 \text{ about.}$$

Let T = torque;
C = current (in amperes);
N = lines of force in armature;
K = turns of wire on armature.

Then,

$$K = \frac{13.56 \times 2\pi T \times 10^7}{NC} =$$

$$\frac{13.56 \times 2\pi \times 8.75 \times 10{,}000{,}000}{850{,}000 \times 3.75} = 2{,}340 \text{ nearly, say } 2{,}400.$$

Armature resistance to equal 2 ohms = No. 15 B. & S. gauge wire (brushes in series). (*b*) Exactly as above.

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(383) (*a*) Fig. 1 is supposed to represent an iron bar that has been pulled apart in a testing machine. The marks *A*, *B* were originally 1 inch apart. After rupture this distance is increased to 1½ inches, giving an elongation of 50 per cent. Fig. 2 represents a bar of the same size and material, bent cold. The marks *A*, *B* were 1 inch apart before bending, and 2 inches afterwards, giving 100 per cent. elongation. Why can the fibers stand so much more elongation in the latter than in the former case? (*b*) Please give roughly the process of making bicycle tubing—seamless, welded, and Mannesmann.

S. D. C., Washington, D. C.

ANS.—(*a*) In a test piece subjected to a direct pull, as is the case in Fig. 1, the elongation is at first pretty evenly distributed along the entire length of the specimen, but, soon after the yield point is passed and the molecules begin to be rapidly redistributed, a concentration of the flow takes place at some particular section, owing to a slight difference in the net area or the molecular structure at that point. The result is a very considerable elongation and reduction of area in the immediate vicinity of the point of fracture, while the deformation of the specimen at some distance from the fracture is comparatively small. If, instead of the length of 1 inch, you had taken a length of only ½ inch as a unit (¼ inch on each side of the fracture), you would have found the percentage of elongation much greater than 50 per cent., and probably greater than 100 per cent., of Fig. 2. When the specimen was bent cold, as in Fig. 2, the conditions prevented the rapid local deformation, and the deformation was consequently distributed quite evenly over the whole original section of 1 inch, the result being that there was an elongation in that length of 100 per cent. without fracture. The above considerations have led many engineers to regard the reduction of area as a very uncertain and unsatisfactory test of the quality of iron or steel, and it is now omitted from some specifications; in fact, a large reduction of area, that is, a large local deformation, is by many regarded as an indication of a lack of homogeneity in the material, and consequently an indication that the quality is inferior. (*b*) See HOME STUDY MAGAZINE, May, 1897, Answers to Inquiries, No. 118.

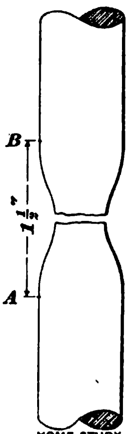

FIG. 1.

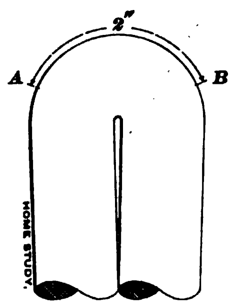

FIG. 2.

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(384) Kindly inform me what pitch of blade would be required to absorb 5 horsepower on a propeller wheel of 13 inches diameter, the speed of engine being 400 revolutions per minute.

E. O. B., Detroit, Mich.

ANS.—A propeller wheel 13 inches in diameter will not work, since the pitch required to absorb 5 horsepower is too great to get good results. A wheel about 21 inches diameter, and having a pitch of about 33 inches, will be more suitable for 400 revolutions per minute.

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(385) Kindly tell me where I can get the best books on hardening and tempering steel.

F. H. W., Pawtucket, R. I.

ANS.—We do not know of any book entirely devoted to the tempering of steel. You will find receipts for several tempering liquids on page 265 of "The English and American Mechanic"; price $2.00. This book you can obtain from The Technical Supply Company, Scranton, Pa.

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(386) Please illustrate and describe the instrument called the *tachometer*, used for indicating the velocity with which a dynamo, motor, or engine is rotating.

W. E. B., Panther, Iowa.

ANS.—The tachometer will be made the subject of an article at an early date.

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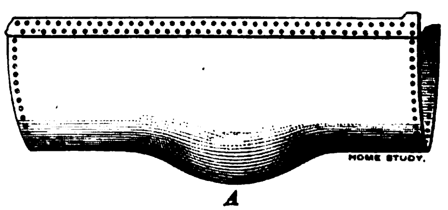
(387) I would like to ask a question about a boiler that is bagged. G. M. P., Constitution, Ohio.

ANS.—Perhaps our correspondent means by this that he desires an explanation of the term, together with some general information on the subject. The particular kind of failure known as "bagging"—as shown at *A* in the annexed figure—occurs sometimes in externally fired cylindrical boilers. It is due to the plates becoming unduly heated. This overheating may be due to an accumulation of scale at this point, thus preventing a free transfer of heat through to the water. A case of bagging was once found to be due to a greasy rag which had been left lying inside



A

on the bottom of the shell. Anything of this nature is especially conducive to overheating. When any of these causes are present, the plates get gradually hotter and hotter until they can no longer resist the stress of the steam pressure acting on the inside, and the result is they yield and present a bulging appearance as shown.

***

(388) Do you know of any receipt for cleaning calcimined walls and wall paper?

H. P., Vancouver, B. C.

ANS.—Bread—one day old, well rubbed over the surface, and dusted off with a clean brush.

HOME STUDY MAGAZINE

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THE COMMON ENGLISH BRANCHES.

Thos. Quinton.

THE UTILITY TO THE TECHNICAL STUDENT, OF SPELLING, READING, WRITING, ARITHMETIC, GRAMMAR, GEOGRAPHY, AND HISTORY.

THE common English branches, according to the usual classification, include spelling, reading, writing, arithmetic, grammar, geography, and history. Why should the technical student spend a large part of his time in learning branches of knowledge which do not appear to have a direct connection with the object in view? Why need I be a grammarian to be a good plumber? Why must I be able to locate the Windward Passage, and state for what Singapore is noted, before I can become an expert electrician? Why must I learn that cannon were first used at the siege of Constantinople, in order to become a gunner?

Questions of this kind are often asked by those who are striving to advance to the best positions in the industrial world, who are not prepared in education and experience to take a suitable position and yet are so impatient to be in the busy whirl of life that they wish to spend the least possible time and energy on preliminaries.

Such questions, however, only betray the questioner's condition; he is endeavoring to hide with words his lack of knowledge. Better would it be to ask: What is the nature of the common English branches? What is the nature of the art or craft which I seek? What is my own nature? What are the power and utility of the studies in common English? What knowledge will my position in life require? The consideration of these questions will bring one far towards a solution of the problem. It will lead the mind from confusion to orderly, logical thought.

The conviction is universal that a knowledge of the three R's—reading, 'riting, and 'rithmetic—is necessary for all, without regard to occupation or position in life. Regarding these subjects, therefore, as essential, and their usefulness above discussion, we have left for consideration the remainder of our list—spelling, grammar, geography, and history.

The greatest advantage of good spelling is its effect upon others. Dr. Brooks says, "There is no great credit in being a good speller, but there is great discredit in being a poor one." To avoid this discredit, every one who has his future success, or even his present advantage, at stake, should be a good speller. One cannot afford to have his worth in other respects measured unjustly on account of poor spelling. Besides being wrongly judged, one will be misunderstood through poor spelling. The intention of a writer is often obscured by bad orthography. Then, one who keeps up to the times, and wins real success in any trade, must read and study matters pertaining to that trade. A good reader must be a good speller. He must be well acquainted with the forms of words, so that the sense of what is read will come freely. He must also know the meaning of words. The successful man must be a ready man. It won't do for a practical, busy man, in reading and writing, to require a dictionary at his elbow, or to be stopping to think how many *t's* in "hatter," or whether the *i* comes before the *e* in "receive." In the path to success, poor spelling makes poor progress.

To good spelling must be added a practical knowledge of grammar. Grammar treats of the construction of language and the art of using language. Language has two uses,

first for thinking, and second for expressing thought. A German thinks in German, and an Englishman in English. A new word or new meaning to an old word brings an added means of thought. Inaccurate language makes inaccurate thought. An expression of a complete thought is called a *sentence*. A word is only a part of a thought expressed. And chapters, books, etc. are successions of thought expressed. So that the sentence is the unit of language. It is the province of grammar to deal with that unit as a whole and in its parts. That part of grammar which treats of words with regard to their uses, changes, and classification, is called *etymology*. And the part that treats of the relations of the different parts of the sentence and of the sentence itself, is called *syntax*.

Knowledge is essential to progress. The exercise of thought and the expression of it are the great means of gaining knowledge. The different forms and principles of expression and the liabilities to error must be understood in order to enable a person to use language successfully on a subject with which he is not familiar. A student desires information. He plies with interrogations people capable of informing him, but fails to obtain satisfaction—all because he does not make clear what he wishes to know. He writes to some one versed in the subject, and many times fares little better. He does not understand the use of language well enough to make himself understood. His thoughts and his words sound well enough, but they lack meaning. They answer the purpose in idle conversation, but not in business. He cannot be corrected, because he does not understand grammar and grammar language.

In addition to furnishing a student with a knowledge of language, the study of grammar renders him competent to appreciate advantageous criticism. It tends to make the mind orderly and scientific, cultivates a taste for correct expression, and, if diligently exercised in speaking and writing, produces a scholar adept in saying what he means.

Geography, though not really itself a science, embraces something of nearly all the sciences. It contains truths in astronomy, botany, zoology, physics, civic government, anthropology, etc., besides many facts about the known world, most of them well classified. It is the most enchanting of all the studies of the common English course. To fill with credit and ease the position in all the phases of life in which his technical education will place him, a man is bound by the laws of good morals and by good manners, as well as by propriety, to have a fair knowledge of the world about him. One who goes among his associates, contributing nothing of knowledge himself, absorbing what he may from those who have learned, is like a beggar who takes from others but earns nothing himself. He is a social mendicant. Every one has to learn much from others. It is, therefore, a duty and a necessity for every one who would make progress to have knowledge of his own to give to others. To fill such a requirement the study of geography is indispensable. Geography is the greatest repository of interesting and intelligent information open to the ordinary student. Geography, treating of what can be seen in the several parts of the world, is easily acquired. Still, its varied subjects, its many facts, and its philosophic explanations of different phenomena, make it a rich embellishment to the common English course. The present war has manifested the high premium at which even a knowledge of the commonplace facts of geography are estimated by all our people. So that a knowledge of geography, while a direct advantage to the student, is indirectly a still greater advantage, for it enables him to agreeably gain information from his associates—"To him that hath shall be given."

The ultimate object of an education is efficiency, that is, the power to accomplish results. To gain this power there are two essentials: The gaining of knowledge, and the development of one's powers. The development of one's powers is called *culture*. Culture, to be most effective, must be harmonious. If some faculties are deficient, the whole mind feels the loss. Of the mental powers, the faculties most needed are those of imagination, memory, mathematical reasoning, probable reasoning, good judgment, and close attention. Attention is the power to hold the mind on one subject for a considerable length of time. The trouble with a technical education is that it does not give a sufficient culture, especially harmonious culture. So that the technical student should not think of getting along with anything less than all the branches of the common English course, thoroughly studied and mastered, that he may reap the benefit in knowledge and culture that their possession confers upon him.

Spelling cultivates the memory. Arithmetic, especially oral arithmetic, cultivates clearness of expression, judgment, and mathematical reasoning. Grammar cultivates the analytic faculty, and induces a habit of order

and system in the classification of objects—both of them very essential qualities. The study of history develops the memory because of its chronological order of events, and because its facts cannot be worked out, but must be remembered. History also enlivens the imagination. The student will imagine the personages, the armies, the battles, the scenes and events as they are word-painted on the printed page. History, thoughtfully studied, will develop probable reasoning—a faculty most useful in all the departments of practical life.

But more than any other study history is essentially moral. It leads the student to love and emulate the good, and abhor the bad. A large portion of Divine Truth is given to us in the form of history—not without the wisest purpose. History teaches by combined precept and example, and by vivid contrast of the noble with the ignoble. It appeals to the sensibilities as well as to the intellect, and they in turn act on the will and produce lofty purposes.

> "Lives of great men all remind us
> We can make our lives sublime."

Lofty purpose is the motive power of personal progress. No purpose insures no advancement. The purpose of attaining the most possible wealth and position with the least possible personal worth and efficiency arises from an ill-fated paucity of soul and mind. Such a policy is detrimental alike to the individual who practices it and to the public which is imposed upon. In the event of apparent success to the individual, he finds himself in a desert of vanity, frantically trying and miserably failing to convince the world of his great importance. His end is as hopeless as his beginning. Water is bound to seek its level. The example of King Solomon and the advice he gave will never be superseded: "With all thy getting, get understanding."

MECHANICAL ONIONS.

D. Petri-Palmedo.

A Reminiscence of the Early Days of Electric Street Cars.

THERE is a tendency with beginners in the art of machine building to make "mechanical onions." By this term are not meant *artificial* onions, or onions *grown by machinery*, but machines that resemble onions in that they are built of many pieces, so arranged "inside one another" that in order to inspect or repair a certain piece, the whole machine has to be taken apart, down to the very last screw or bolt. Machines of this kind look very fine on paper, are splendid subjects for the patent office, and are often the foundations on which stock companies are started.

Think of it! Not very long ago a steam engine like a large cheese box—about 20 inches in diameter and 18 inches high and said to develop some 300 or 400 horsepower—was a great deal talked about as the most compact motor ever built. The news came from the far west and a certain sensational New York paper contained the first account of it. The inventor, so the story went, had already disposed of the United States patent, and was negotiating the sale of his foreign rights for fabulous sums. He has since disappeared, however; at least, nothing has been heard of him for many months, nor of his motor either. But, to be serious, it is a fact that a great many otherwise excellent devices prove failures in practice on account of too much compactness and inaccessibility of the vital parts. A practical example will probably best illustrate what this means.

In the accompanying sketches, Figs. 1, 2, and 3, is shown a very pretty mechanism, originally designed for a power-transmitting and speed-reducing device for electric street cars. The ideas upon which it is based are very clever, and the machine ran to perfection until it was put to the work for which it was intended, when the "onion" came out so strong that the device had to be abandoned, and replaced by something else. In a modified form and for different work the mechanism may have proved satisfactory. Here it shall serve as a warning example.

It is first necessary to briefly describe the mechanism. Fig. 1 is a plan view of the machine, and presents a perfectly charming outside appearance—nothing but plain cylindrical surfaces, four bearings, and a double

sprocket wheel. The end of the shaft extending out a little on the left was coupled with the electric motor, which ran at quite a high speed. At B and B' are brake disks, either one of which could be clutched by brake shoes C, C' by throwing a lever on the platform of the car to the right or left. When this lever stood in the middle, both disks were free, and then the sprocket wheel S in the center of the mechanism would be at a standstill; but on clutching the left-hand disk B the sprocket wheel would revolve at a speed much lower than that of the shaft A, and on clutching the disk B' the speed was still further reduced. From the sprocket wheel the power was transmitted to the car axles by means of chains. It was thus possible to give the car two different speeds at will, by purely mechanical means. This result was achieved by a system of planet gearing inside, arranged as disclosed by the sectional elevation, Fig. 2. Commencing at the left, the shaft A has an eccentric E, upon which is mounted, free to turn, a pinion P. This pinion meshes with an annular gear-wheel G, which latter is bolted to a sleeve H having flanges for that purpose. The sleeve runs loosely on the shaft A, and is itself supported in bearings I and I' of the main frame. Besides the two end flanges for the annular gears, the sleeve H has a third, central flange, to which is bolted the double sprocket wheel S. On the right-hand side of this sprocket wheel, the parts are repeated with this difference only: that the ratio between the two gears P' and G' is different, and the throw of the eccentric E' is smaller. To complete the mechanism, there are the above mentioned brake disks B and B' at either end, also running loose on the shaft A, and the brake shoes C and C' operated from the platform. Each disk is connected with its respective pinions P or P' by an *Oldham coupling* O, a familiar device, allowing the transmission of rotatory motion between parallel shafts. Fig. 3 is an illustration of this coupling, the member a forming part of pinion E, the member b, part of disk B, and the lugs of the intermediate member c sliding one way in the grooves of a and the other way in the grooves of b. The mechanism will now be understood.

When the shaft A revolves with both disks free, the eccentrics will be thrown around the inner circumference of the annular gears and, rolling thereon, will communicate motion to the disks B and B' through the couplings O, O'. As soon, however, as one of the disks is clutched and brought to a standstill, its respective pinion is prevented from revolving, but not from following the motion of the eccentric; therefore, in doing so, it takes the gear-wheel G along at a reduced speed. The motion is thus communicated through the sleeve to the sprocket wheel and thence to the axles. The shaft A is supported on both ends in bearings, and is made hollow so that oil can enter from a well on the right end and be distributed through holes in the shaft all over its bearing surface. So much for the mechanism.

Fig. 1.

Fig. 2.

It will at once be recognized that the great difficulty with this machine is proper lubrication. The shaft A has no less than seven journals, all of which are under more or less

heavy pressure, and all running at high speed. The sleeve has two journals. There are four more sliding contacts in the couplings $O\,O'$, making, in all, thirteen sliding contacts, in addition to the two rolling contacts of the gears. There was no trouble experienced in supplying the sleeve journals with oil, nor was there any difficulty whatever with the gearing or couplings, but it was found impossible to properly lubricate the shaft journals, although oil seemed to circulate freely, doubtless because some of the little passages soon became clogged, and, as there was no way—excepting the one which will be spoken of presently—to get at the shaft, it being the very core of the onion, one had to trust to luck. As a matter of fact, there was more or less trouble right in the center of the shaft. Occasion then arose for frequent taking apart and assembling the whole machine, for the sole purpose of cleaning out the little oil passages. Now, let us see what it meant to take the shaft out, sometimes, in the course of experimental trips, right on the open track. First, the chains had to be taken off the sprocket wheels, necessitating the disconnection of the chains by loosening two chain bolts. If on the open track, this was done by crawling under the car, at the expense of two minutes' time and usually a pair of trousers or overalls at the best. Next, the sprocket wheel S had to be removed (for which purpose it was made in sections), by unscrewing 6 bolts; time, 5 minutes. The 8 capscrews of the four bearings came next; time, 7 minutes. Then the whole mechanism was hoisted out of the frame by means of a block and fall, which was carried for the purpose, as part of the wrecking outfit, under one of the seats of the car; time, 5 minutes. The disks $B\,B'$ were then slipped off, together with the couplings and the pinions; time, ½ minute. Finally, the right-hand eccentric had to be removed by loosening a setscrew; this occupied another ½ minute. Then, at last, the shaft could be *pulled* out to the left, if it was not stuck so fast that it had to be forced out. If it could be pulled out, the

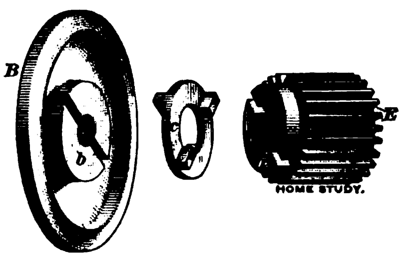


FIG. 3.

whole operation of taking apart and reassembling took from 40 to 45 minutes. If the shaft was seized and could not be easily removed—and this used to happen at intervals at the beginning of the existence of this machine—usually, one of the small steam cars running on the road at the time was hailed to tow the electric car in. The engineers got quite accustomed to it after awhile, and all that it was necessary to say, by way of explanation, was, "We've had trouble again with the 'onion'".

WHAT DOES A DYNAMO GENERATE?

FAMILIARITY with an every-day form of expression often prevents us from questioning the accuracy of its meaning or giving it any serious attention. We frequently hear people speak of a dynamo as a machine for generating electricity. Is it true that a dynamo generates *electricity?*

Before attempting to answer the question, let us consider one or two parallel cases. A pump is used for forcing water through a pipe, but the pump does not generate *water*. It simply generates a *pressure* which causes the water to flow toward the point of least resistance. The same thing takes place with a blower for producing a blast of air. The blower does not generate *air* but simply pressure. So it is with a dynamo. When there is a difference of electrical pressure or potential between any two points on a conductor, the electrical current will flow from one point to the other. It is pressure, then, that the dynamo generates. The action of the machine simply raises the electrical pressure at one point of a circuit, thereby causing the current to flow. In other words, the dynamo generates *electrical pressure.*

GEOMETRICAL PROGRESSIONS.

Antonio Llano.

Do We Gain Anything by Getting a Life-Insurance Policy and Not Dying?—Surprising Results Obtained by Continued Multiplication.

It is a very common thing to have a life-insurance agent come to us with such a proposition as this: "We will insure your life for $5,000 on the following terms: You are to pay us $150 a year in quarterly payments of $37.50. If you die at any time before the expiration of a term of 20 years, your family is to receive, then, the full amount of $5,000. If, at the end of 20 years, you are still living, we will either pay you the $5,000 in cash, or give you an annuity," etc., etc.

We shall assume that the person to whom this proposition is made is young and enjoys good health, and therefore, his expectation (for what young man does not *expect* to live 20 years longer?) of living to the end of the stipulated term is well founded. Under these circumstances, he will naturally ask himself, "Leaving aside the probabilities of death, which are very few, how much of my money shall I get back, and, if I get more than what I have paid, what rate of interest will correspond to the excess I receive? Would it not be more profitable for me to invest my money in some other business, or simply place it in the bank at 4 or 6 per cent., compound interest? And, in the latter case, is the difference worth running the risk of dying without having my life insured, for the sake of making an otherwise better investment of my savings?"

The reader will see at once that this is a problem relating to compound interest; but the problem is of a somewhat complicated nature. Let us assume that the payments are made yearly in advance. At the end of 20 years, the amount paid will be $150 \times 20 =$ $3,000, and, as the amount received is $5,000, there will be a gain of $2,000. If, instead of investing our money in this manner, we placed it at 5 per cent. compound interest, what would the gain be?

As we pay $150 at the beginning of the first year, this amount would draw interest for 20 years; the amount paid at the beginning of the second year would draw interest for 19 years, and so on; the amount paid at the beginning of the twentieth year would draw interest for only 1 year. Let us first consider $150 drawing interest for 20 years. The rate of interest being 5%, $1 would become, at the end of 1 year, $1.05, and $150 would become 150×1.05. During the second year we should have 150×1.05 dollars drawing interest, and, as each dollar becomes 1.05 in a year, the total amount would become $150 \times 1.05 \times 1.05 = 150 \times 1.05^2$. Likewise, during the third year we should have a capital of 150×1.05^2 drawing interest, and its value at the end of the year would be $150 \times 1.05^2 \times 1.05 = 150 \times 1.05^3$. Proceeding in this manner we arrive at the expression 150×1.05^{20}, as the value of the $150 at the end of 20 years. The operation of raising 1.05 to the twentieth power may be performed by continued multiplication; but, as this process might last through the contemplated term of 20 years, it is better to use logarithms.

As the method of computing compound interest is of great value, we shall state the results of the preceding simple reasoning in a general formula. If an amount A is placed at r per cent. compound interest during a period of n years, its value C, at the end of the nth year, will be

$$C = A\left(1 + \frac{r}{100}\right)^n,$$

or, for logarithmic computation,

$$\log C = \log A + n \log\left(1 + \frac{r}{100}\right).$$

Now to proceed with our example. The $150 invested at the beginning of the second year would become 150×1.05^{19} at the end of the twenty years; the $150 invested at the beginning of the third year would become 150×1.05^{18}, and so on, up to the last year, in which the $150 invested would become 150×1.05. The total amount T at the end of the 20 years would, therefore, be

$$\begin{aligned} T &= 150 \times 1.05^{20} + 150 \times 1.05^{19} \\ &\quad + 150 \times 1.05^{18} + \dots + 150 \times 1.05 \\ &= 150\,(1.05 + 1.05^2 + 1.05^3 + \dots + 1.05^{20}). \qquad (1) \end{aligned}$$

Here again we might compute each term within the parenthesis by means of a table of logarithms, and then add the results; but the amount of labor involved would be very great, and, as is always the case when many operations are performed and many results

combined, the probabilities of making mistakes would be much increased. By observing the terms inside the parenthesis we notice that they constitute a series in which each term is obtained from the preceding by multiplying the latter by the fixed quantity 1.05. A series of this kind is called a *geometrical progression.* Like an arithmetical progression, it has some peculiar properties, and from these properties the sum of all the terms may be expressed by a very simple formula, which greatly shortens and facilitates calculation.

According to the definition, a geometrical progression having n terms may be represented as follows:

$$a,\ a\,r,\ a\,r^2,\ a\,r^3,\ \ldots\ldots\ a\,r^{n-1}. \qquad (2)$$

The first and the last term a and $a\,r^{n-1}$ are called the *extremes*, and the constant quantity r, by which each term is multiplied in order to obtain the following, is called the *common ratio*, or simply the *ratio*, of the progression.

The way of finding the value of any term is obvious from the law of the formation of the series. Thus, the second term, which is preceded by *one* term, is equal to $a\,r$, or $a\,r^1$; the third term, which is preceded by *two* terms, is equal to $a\,r^2$; and, in general, any term is equal to the first term multiplied by a power of the ratio whose exponent is equal to the number of terms preceding the term in question. As there are n terms in the progression, the last term is preceded by $n-1$ terms, and its value is therefore $a\,r^{n-1}$.

The ratio r may be either greater or less than 1; in the first case, the progression is called an *increasing* progression, because each term is greater than the preceding; in the second case, the progression is called a *decreasing* progression, because each term is less than the preceding. The following are examples:

$$3\ ,\ 12\ ,\ 48\ ,\ 192\ ,\ 768 \text{ etc.}$$

$$\frac{1}{3}\ ,\ \frac{1}{12}\ ,\ \frac{1}{48}\ ,\ \frac{1}{192}\ ,\ \frac{1}{768} \text{ etc.}$$

The ratio of the first progression is 4; that of the second is $\frac{1}{4}$; both may be easily reduced to the general form, as follows:

$$3\ ,\ 3\times 4\ ,\ 3\times 4^2\ ,\ 3\times 4^3\ ,\ 3\times 4^4 \text{ etc.}$$

$$\frac{1}{3}\ ,\ \frac{1}{3}\times\frac{1}{4}\ ,\ \frac{1}{3}\times\frac{1}{4^2}\ ,\ \frac{1}{3}\times\frac{1}{4^3}\ ,\ \frac{1}{3}\times\frac{1}{4^4}\ , \text{ etc.}$$

The main problem relating to a geometrical progression is to find an expression for the sum of a certain number of its terms. This will enable us to solve a great many problems similar to the one we stated at the beginning of this article. [See formula (1).]

By applying the elementary principles of algebraic multiplication we arrive at the following results:

$$\begin{array}{ll}
\textit{Multiplicand:} & 1 + x + x^2 + x^3 + x^4 \\
\textit{Multiplier:} & \qquad\qquad\qquad\quad 1 - x \\
\hline
\textit{Product:} & 1 \qquad\qquad\qquad\quad\ \ - x^5
\end{array}$$

that is,

$$(1+x+x^2+x^3+x^4)(1-x)=1-x^5,$$

whence, dividing both members by $(1-x)$,

$$1+x+x^2+x^3+x^4=\frac{1-x^5}{1-x}=\frac{x^5-1}{x-1}.$$

As the general conditions are the same, whatever the number of terms may be, we may extend this result to any number of terms, say n, and write,

$$1+x+x^2+\ldots+x^{n-1}=\frac{1-x^n}{1-x}=\frac{x^n-1}{x-1} \quad (3)$$

Returning now to our general progression (2), and calling the sum of its terms S, we have

$$S=a+a\,r+a\,r^2+\ \ldots\ +a\,r^{n-1}$$
$$=a\,(1+r+r^2+\ \ldots\ r^{n-1}),$$

or, by formula (3),

$$S=\frac{a(1-r^n)}{1-r}=\frac{a(r^n-1)}{r-1}. \qquad (4)$$

If the last term of the progression is l, we have seen that $l=a\,r^{n-1}$; therefore, $a\,r^n = l\,r$, and we may write,

$$S=\frac{a-l\,r}{1-r}=\frac{l\,r-a}{r-1}. \qquad (5)$$

For example,

$$3+12+48+192+768=\frac{768\times 4-3}{4-1}=\frac{3{,}069}{3}=1{,}023.$$

$$\frac{1}{3}+\frac{1}{12}+\frac{1}{48}+\frac{1}{192}+\frac{1}{768}=\frac{\frac{1}{3}-\frac{1}{768}\times\frac{1}{4}}{1-\frac{1}{4}}=\frac{768\times 4-3}{3\times 768\times 3}=$$
$$\frac{1{,}023}{3\times 768}=\frac{341}{768}.$$

When the progression is decreasing and the ratio is of the form

$$\frac{1}{r_1}\left(\text{as } \tfrac{1}{2},\ \tfrac{1}{4},\ \tfrac{1}{7}, \text{ etc.}\right),$$

the general formula may be reduced to the following convenient form. Let the progression be,

$$a_1,\ \frac{a_1}{r_1},\ \frac{a_1}{r_1^{\,2}},\ \frac{a_1}{r_1^{\,3}}\ \ \cdot\ \cdot\ \cdot\ \ \frac{a_1}{r_1^{\,n-1}}.$$

By formula (4) we get,

$$S=\frac{a_1\left(1-\frac{1}{r_1^{\,n}}\right)}{1-\frac{1}{r_1}}=\frac{a_1\left(\frac{r_1^{\,n}-1}{r_1^{\,n}}\right)}{\frac{r_1-1}{r_1}}=\frac{a_1\,(r_1^{\,n}-1)}{(r_1-1)r_1^{\,n-1}} \quad (6)$$

Or, if we put $r_1^{\,n-1}=l_1$, whence $r_1^{\,n}=l_1\,r_1$,

$$S=\frac{a_1\,(l_1\,r_1-1)}{(r_1-1)l_1}. \qquad (7)$$

Examples:

$$\frac{2}{5}+\frac{2}{15}+\frac{2}{45}+\frac{2}{135}+\frac{2}{405}=$$
$$\frac{2}{5}\left[1+\frac{1}{3}+\frac{1}{9}+\frac{1}{27}+\frac{1}{81}\right]=\frac{2}{5}\times\frac{81\times 3-1}{(3-1)\times 81}=\frac{242}{405}.$$

$$\frac{1}{7} + \frac{1}{7^2} + \frac{1}{7^3} + \frac{1}{7^4} + \dots + \frac{1}{7^{10}}$$
$$= \frac{\frac{1}{7}(7^{10} - 1)}{(7-1) \times 7^9} = \frac{7^{10} - 1}{6 \times 7^{10}}.$$

In the last example the first term is $\frac{1}{7}$, the number of terms 9, and the ratio $\frac{1}{7}$, and S is found by formula (6); the tenth power 7 is easily computed by logarithms.

Formula (4) may be used for solving the problem we proposed at the outset. It will be remembered [see formula (1)] that the final amount, after 20 yearly investments of \$150 each, was

$$T = 150\,(1.05 + 1.05^2 + \dots + 1.05^{20}).$$

The terms within the parenthesis form a geometrical progression in which $a = 1.05$, $r = 1.05$, and $n = 20$; therefore,

$$S = \frac{1.05 \times (1.05^{20} - 1)}{1.05 - 1},$$

and $$T = \frac{150 \times 1.05 \times (1.05^{20} - 1)}{.05}$$
$$= 3{,}150 \times (1.05^{20} - 1) = \$5{,}208,$$

or only \$208 more than the amount returned by the insurance company. Unless we can invest our savings in a more lucrative way than to put them in a bank at 5% compound interest, counted yearly, it is not a poor bargain to invest them in an insurance policy similar to the one described above; for in this way we get our money back with a fairly good interest, and have the advantage, at the same time, of being insured against such an unpleasant little accident as death. It is always a relief and a satisfaction to leave something to those we love; but, even if we are sufficiently hardened and selfish not to love any one, we ought to take care that we leave at least enough to pay our debts, for we are assured that all creditors on this side of the grave have a fearless and heartless agent on the other side, who never was known to handle any insolvent debtor with gloves, and whose methods of dealing with the unfortunate convicts are simply awful. To this the insurance agents themselves can bear testimony, having it direct from their colleagues, who seldom escape the colored gentleman after they leave their terrestrial habitation.

It may be worth noticing, as a curious fact, that the human mind, owing to its habit of dealing almost always with ordinary addition and subtraction, has developed along an arithmetical rather than along a geometrical line. In problems relating to common addition and multiplication, and where the law of arithmetical progression obtains, we can make tolerably good guesses, and the results of actual calculation seldom differ from guessed values by very large quantities. Where, however, we have to deal with geometrical progression, we are invariably misled by our arithmetical habits, the result being that our guesses and our general idea of the law of increase of quantities by continued multiplication are most ridiculously wrong, and the results obtained by actual calculation are as surprising as they are unexpected. As an illustration of this we may refer to the well known story of the tramp who came to a farmer and asked for employment. "I have all the help I need at present," said the farmer, "and cannot afford to pay any more wages; but, if you will work for your board, I will take you in, and, if you prove yourself a good worker, I may in a few months be able to pay you something." "That is very kind of you," said the tramp, "I have never been used to handling money—never earned any—and the lack of it won't worry me much. But, if you feel any scruples at taking my work for nothing, you may, just to keep up appearances, pay me one cent the first month, two cents the next, and so on for two years; and then, if my work is satisfactory and I am pleased with it and with you, I will stay for the monthly salary I shall have at the end of the two years." The farmer, of course, exploded with an outburst of laughter—that contemptuous and patronizing laughter of him who stands high up on the ladder of both wealth and knowledge. The idea of 24 cents first passed through his mind, then 48 cents, and finally, by a process whose very indefiniteness challenges all description, he settled on "about one dollar" as the final wages he should pay the tramp at the end of two years. "Very well," he said, "you don't seem to be very ambitious; but, if you do well, I will pay you a little more than what you ask for." The winding up of this story is that, at the end of two years, the farm with all its belongings was the property of the tramp, while the farmer was happy to work in it for his meals and a small pittance of cash per month. The reason for this is not far to seek: the wages he paid the tramp increased in geometrical progression as follows:

$$1,\ 2,\ 2^2,\ 2^3,\ 2^4,\ \dots\ 2^{23}$$

The salary at the end of the 24th month was, therefore,

$$2^{23} = 8{,}389{,}000 \text{ cents} = \$83{,}890,$$

which is, perhaps, a little more than either the tramp or the farmer had ever seen.

The inventor of the game of chess (a Chinaman) is said to have been offered by the

emperor anything he might wish for, as a reward for his marvelous invention. "Your subject," said the inventor with becoming humility, "is already sufficiently rewarded by the pleasure he has afforded your majesty; but, since your majesty insists, he will be satisfied with a few grains of rice: one for the first square of the chess board, two for the second, four for the third, eight for the fourth, and so on to the sixty-fourth square." The reader may amuse himself by finding the number and the value of these "few grains of rice." *

We have now to consider a problem of frequent occurrence relating to decreasing geometrical progressions. Let us take the progression

$$a,\ ar,\ ar^2,\ ar^3 \ldots,$$

in which r is less than 1. If we have a finite number of terms, their sum may be at once found by the formulas we have given; but it may happen that, from the special conditions of the case, the series has no end. Of this we have an example in the ordinary circulating decimal fractions, as 0.3333 . . , 0.353535 . . . , which are only particular cases of decreasing geometrical progressions, for we have

$$0.3333\ldots = \frac{3}{10} + \frac{3}{10^2} + \frac{3}{10^3} + \frac{3}{10^4}\ldots$$

$$0.353535\ldots = \frac{35}{100} + \frac{35}{100^2} + \frac{35}{100^3} + \ldots$$

The ratio of the first progression is $\frac{1}{10}$, that of the second, $\frac{1}{100}$.

* As a most astounding result of the increase of a quantity by continued multiplication, see the short article "A Monster Diamond for One Cent," in HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., July, 1897.

From arithmetic we know that the circulating fraction 0.333 . . . is equal to $\frac{1}{3}$, and this is expressed by saying that the sum of *all* the terms of the infinite series

$$\frac{3}{10} + \frac{3}{10^2} + \frac{3}{10^3} + \ldots$$

is $\frac{1}{3}$, or, that the series results from the division of 1 by 3, or again, that the true value of the series is $\frac{1}{3}$.

Let us see if we can find a simple general expression for the sum of the terms of a decreasing geometrical progression, when the number of its terms increases without limit. Denoting this sum by S we have

$$S = a + ar + ar^2 + ar^3 + \ldots\ldots$$
$$= a + r(a + ar + ar^2 + ar^3 + \ldots\ldots) = a + rS,$$

whence,

$$S = \frac{a}{1-r} \qquad (8)$$

By the use of this formula we find,

$$.333\ldots = \frac{.3}{1-\frac{1}{10}} = \frac{.3}{.9} = \frac{3}{9} = \frac{1}{3}.$$

$$.3535\ldots = \frac{.35}{1-\frac{1}{100}} = \frac{.35}{.99} = \frac{35}{99}.$$

$$\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \ldots = \frac{\frac{1}{2}}{1-\frac{1}{2}} = 1.$$

The applications of geometrical progressions to mechanical and physical problems are very numerous; but space does not allow us to give any illustrations at present. As is the case with arithmetical series, geometrical series are often employed in investigations that would otherwise require the use of the higher mathematics, and for this particular purpose, formula (8) is of great value in the determination of the *limit* (the true value) of the sum of an infinite number of decreasing terms.

A WELL BUILT HOUSE.

A MAN'S house may be likened unto a mirror—reflecting the character of the indweller. Bacon says, "Houses are built to *live in* and not to *look on:* Therefore, let *use* be preferred before uniformity, except where both may be had."

In this age of hurry-scurry—where every man seems to be striving, as in a race, with the devil as a close second—it is difficult to obtain a well constructed house, in the full sense of the term.

The owner who is fortunate enough to obtain a house that is well built has good reason to express his praise of the architect, contractor, and artisans. Ian Maclaren aptly specifies that, "He hath done a great thing who hath built a good house, a house where people may live with self-respect, and whose very walls will stimulate them to do their own work better, because one very hand they see the witness of an honest man's handicraft."

ELECTRIC. LAUNCHES.

E. W. Roberts.

ELECTRIC LAUNCHES AT THE WORLD'S FAIR—LOCATION OF THE PARTS—THE MOTOR—VALUE OF THE METER—TABLE OF DATA.

A VISITOR to the World's Fair at Chicago in 1893 stood gazing at the water from one of the numerous bridges spanning the many lagoons for which the "Great White City" was famous. Suddenly, and without a warning sound, a slender object darted from beneath the bridge, causing the visitor to start with fright, and later to laugh at his fears. The slender object was an electric launch gliding through the water without sound or tremor.

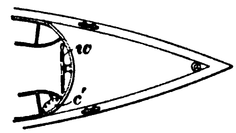
It was at the Fair that the electric launch practically saw its birth, and since 1893 it has become a regular factor among pleasure craft. Although not suitable for voyages of any great extent, still, as a yacht tender and for short voyages, during which the launch will never be at any great distance from the source of power supply, it is an ideal craft. No licensed engineer or pilot is needed, and, in fact, a person without the least mechanical knowledge may operate one satisfactorily. The storage battery which supplies the current can be charged from any source of direct current, and by the assistance of a rotary transformer an alternate current may also be used. For isolated places, the windmill or the gasoline engine is perhaps the most available for driving a charging dynamo; or, where a small stream is at hand, water-power would be the most convenient.

Twenty-nine electric launches were used upon the inland water courses at the World's Fair. A good illustration of one of these boats is shown in Fig. 1. These launches were capable of carrying 30 passengers, and with motors having between 6 and 8 available horsepower, made the entire trip of 4 miles, including stops, in 45 minutes. The speed controller was so arranged that four speeds were available when going ahead, and two speeds when going astern. Each boat was supplied with an air whistle, operated by a small hand pump, for signal purposes, and the shrill scream of these whistles was the only sound to warn other craft of the approach of the electric launch.

FIG. 1.

Fig. 2 shows the arrangement of the storage cells and the electric motor in a western type of electric launch. The cells *b*, *b* are placed on either side of the boat beneath the seats. The motor *M* is shown at a point near the center of the boat beneath the floor. It is usually of the four-pole type, wound expressly for slow speeds so that the propeller shaft *s* can be connected directly to the armature of the motor without the use of reducing gears, thus avoiding the annoying roar which gears nearly always produce. The thrust bearing at *t*, usually provided with ball bearings, prevents an endwise motion of the shaft. The propeller shaft

passes through a tube at *f*, while a form of packed joint at *g*, called a stuffingbox, prevents water from entering the boat around the shaft. By setting the shaft *s* at an incline, as shown, the propeller *P* is brought well below the surface of the water, giving it a better grip than if it were nearer the surface, and insuring the propeller against frequently rising out of the water when the boat is "pitching." The motor is controlled either by means of a hand wheel, as shown at *c*, or by means of a handle *c′*, as illustrated in the small sketch at the right of the figure.



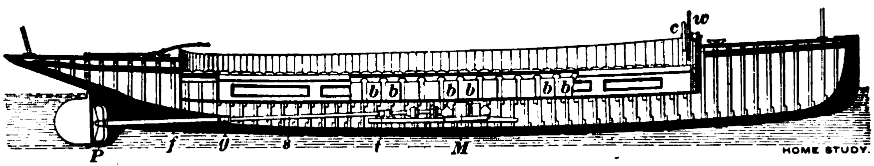


Fig. 2.

The operation of a controller can be understood by referring to the diagrams in Fig. 3. A set of 20 cells is shown in the diagram, divided into 4 groups of 5 cells in each group. Each group is marked with a separate letter. For instance, group *A* has all the cells in the group marked with the letter *A*. This group is an example of all; the cells are connected in series—the positive terminal of one cell is connected to the positive terminal of the next. A conductor is attached to the end terminal of the right-hand cell, say the negative, and to the positive terminal of the left-hand cell. These conductors, marked *g* and *h*, are then connected to contact points on the controller. The conductors for the other groups are connected in the same manner to other contact points on the controller.

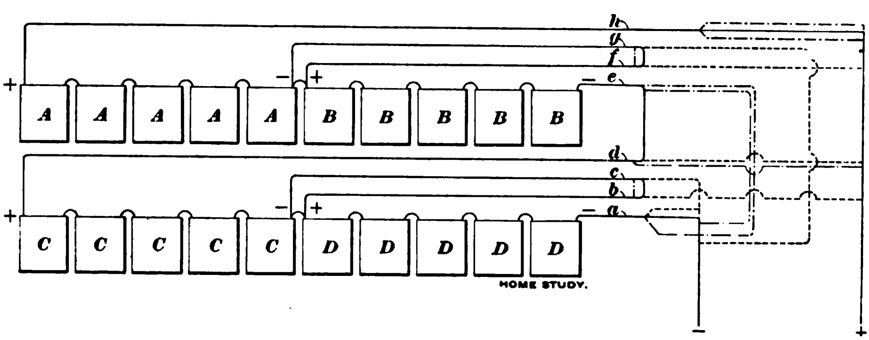


Fig. 3.

The controller is then arranged so that the separate groups may all be connected in series for the highest speeds, in series multiple for a medium speed, or in multiple for the slowest speed, thus giving three speeds for the motor, and, consequently, three speeds for the launch, by altering the voltage in the circuit. The various connections are shown by lines of different construction. The series connections for the fastest speed are indicated by full lines ———, the series-multiple connections by dots and dashes —·—·—·—, and the multiple connections by short dashes - - - -. For the reader who is not familiar with wiring plans it should be stated that, where one wire crosses another without being in electrical contact, the cross is indicated by a half circle.

The electric launches in use at the World's Fair have been superseded by the launch shown in Fig. 4. In this style of launch both motor and batteries are placed beneath the floor, giving the roomy cockpit shown in the figure. A unique innovation is shown in the substitution of wicker chairs and tables for the usual seats along the sides of the cockpit, as the open space is called.

The motor is shown in Fig. 5. It is a special type, having 4 poles and 2 brushes, and is expressly wound for the slow speeds required for driving the electric launch. It has a ball-bearing thrust, and all bearings are self-lubricating, so that they need but

little attention. The whole is enclosed in a box lined with sheet lead, thus rendering the motor proof against moisture. Both propeller and propeller shaft are made of bronze, in order to resist the corroding action

Fig. 4.

of salt water, which would soon destroy them if made of iron or steel.

The storage battery may be of any good type, of which there is a number on the market. They are invariably enclosed in hard-rubber cells having a tight-fitting cover, so that the battery liquid will not splash out and damage the woodwork of the launch.

In order to enable the operator to know the condition of his batteries at any time, a combined voltmeter and ammeter is of great assistance. This acts as an indicator, telling him just how much reserve power he has in his battery at any time; and it will frequently prevent his having to tie up to a dock or to ask for a tow because of the batteries being exhausted. By its use the operator may also guard against exhausting the battery to such an extent as to injure it.

The tabulated data in next column regarding a common type of electric launch, will probably be of interest to the reader.

For short spurts, these boats are capable of speeds about ⅓ greater than those given in the table. The speeds given can be kept up for a continuous run of from 5 to 6 hours. If the runs are intermittent, the total distance will be the same as if the boat was run continuously for 5 or 6 hours. At lower speeds, the charge will last much longer, but fast running uses up the charge much more rapidly. Recharging takes from 4 to 6 hours, according to the amount of current that has

Length Over All. Feet.	Beam. Extreme.	Free-Board.	Maximum Draft.	Average Speed. Miles per Hour.
25	6′ 0″	1′ 8″	2′ 0″	5
30	6′ 4″	1′ 6″	2′ 3″	5 3/4
36	6′ 10″	1′ 10″	2′ 6″	6 1/4
[illegible]	7′ 6″	2′ 3″	2′ 8″	7 1/2

been used since the previous charge. Usually, these boats can be run all day by making use of the time that they lie at the docks for recharging. The charging switchboard may be provided with an automatic switch, so that the batteries may be connected to the charging terminals when tied up for the night, and the current broken by the switch as soon as the batteries are fully charged.

A great number of these craft are now being used as yacht tenders and at numerous summer resorts. They are especially applicable for electric street railways having access to a body of water. Trolley parties may then be given a boat ride in addition to the regular run.

The great convenience of prompt starting and of absolute control makes them excellent craft to place in the hands of the novice. The absence of smoke, of dirt, and of noise makes them favorites with the gentler sex, and the larger amount of room gives a greater seating capacity for the same size boat than for any other power launch on the market.

LUBRICANTS.*

H. Rolfe.

Sources of Vegetable Oils—Tallow and Other Animal Fats—The Mineral-Oil Industry; Its Immensity and Importance—Graphite.

CASTOR OIL.—This is also produced in India, the lower qualities being used in soap making. It is extensively used in medicine as a purgative—the oil used for this purpose being pressed out without heat. The castor oil plant has been transplanted to various suitable climes, and is largely grown in some of our western states, the manufacture of this oil being engaged in on a large scale in Illinois. The oil is extracted by heat and pressure; after two or three repeated pressings and corresponding yields of oil (of diminishing quality) the mass is treated chemically, as in the case of palm oil, a little more being thus extracted. The first yield is used medicinally, as little heat as possible being used in its extraction; the other qualities are used for lubrication, etc. Both these kinds have to be purified before use.

Cottonseed Oil.—Here again, the United States are right ahead, there being several mills in most of the southern states devoted to the production of oil from this seed. Nearly half a million tons of cottonseed are treated annually for the sake of the oil alone. As regards the process employed: The seeds after growing, first of all have the remaining fiber removed from them, and are then pressed into cakes; they are then put into steam-jacketed vessels and stirred up in the dry heat thus obtained. This causes the oil to be freed from the cells, the hot mass then being put into bags and treated in a hydraulic press, and the oil thus extracted. The dry cake then remaining is used as food for cattle; 100 pounds of seed yield about 2 gallons of oil.

Linseed Oil.—The seed from which this oil is extracted is grown in India and Russia; this oil is much used as a "dryer" in paint manufacture. It is claimed that when grown in a cold climate its drying properties are increased, but its color spoiled. The oil is extracted similarly to the other oils already described.

Hempseed Oil.—The hemp plant is chiefly valuable for the fiber obtained from it; it is from this that our well known hemp ropes are made. The oil is extracted in the same way as the other seed oils already described, and is chiefly used for lighting and soap making.

Palm Oil.—This is obtained from the outside covering of the palm fruit and is chiefly derived from Africa. The cases, or shells, containing the nuts are thrown into heaps and exposed in the open air, being left thus for 8 or 9 days. This renders it an easy matter to separate the nuts, which are then thrown into holes several feet deep, lined with leaves of the plantain tree; the holes are then covered over and left for several weeks, until the contents are decomposed. The stuff is then taken out and well beaten, until the pulp is removed from the nuts, after which it is boiled until the oil is extracted. The longer the nuts remain buried, the thicker the oil will be, but the quality and odor will be inferior. The oil is then taken down to the coast to await an opportunity of shipment to Europe and America. It is used in candle and soap making, and also in tin-plate works; as is doubtless generally known, the "tin plates" from which our domestic and other utensils are made, are only iron sheets rolled out very thin and coated with tin; these sheets are removed direct from the oil bath to the tanks of molten tin in which they are to be dipped. As this oil does not dry quickly, it is well adapted for this purpose, preserving the surface of the iron from being oxidized (rusted) before the tin has been applied. It is also very largely used in the manufacture of wagon grease, for railroad freight cars, etc.

Cocoanut Oil.—This is extracted from the fruit of the cocoanut palm, which is found in most tropical countries. There are various native processes for extracting the oil, and, as in the case of palm oil, they are rather crude and wasteful. When first extracted, in tropical climes, the oil is white and almost as thin as water, but when taken to cold countries, it solidifies to the consistency of lard, becoming at the same time opaque. It is used in the East Indies for cooking, when fresh, and for soap making, etc. when stale and rancid. It was at one time very largely

* *Begun in the September, 1898, Number.*

used in Europe and elsewhere for soap making, but has been displaced to a great extent by the oil of the palm nut.

Sunflower Oil.—The sunflower seed yields oil when properly treated, and many other plants in Africa, Abyssinia, and India are also fruitful in this respect.

Peanut Oil.—The peanut, or ground nut, is cultivated in tropical parts on account of the oil-yielding properties of its seeds. The seeds are dried in the sun and the oil then extracted by pressure. In Europe, the nuts, after being cleaned have their husks removed and the kernels are then crushed and put into bags and cold pressed, the oil being afterwards filtered. The solid mass then left is ground up and subjected to a high pressure—from 6,000 to 7,000 pounds per square inch—under heat, thus yielding a further quantity of oil which is inferior, however, to that obtained by the cold treatment. Three yields are generally obtained, the last one being fit only for soap making. The first yield is almost colorless, but when exposed it gradually thickens and turns rancid. It has not much value as an illuminant but is used to some extent for lubricating purposes, its chief employment, however, being in soap making. In the countries where grown, it is used for cooking; it is extensively substituted (fraudulently) for olive oil, when sold in Europe. Very often, however, the seeds are exported to Europe and the oil there extracted. Of the whole amount produced in America, Tennessee affords about one-half.

Coming now to group 2—the solid fats—we have first of all *tallow*, both beef and mutton. In its pure state, tallow is still very largely used on railways in Europe for locomotive consumption, and it is also incorporated with other materials to form that beastly compound known as *axle grease*, which, however, is valuable in its way. This grease consists of palm oil, tallow, soap, and water, which ingredients are boiled together in large iron boilers, and then run off and cooled. It contains, on the average, from 45 to 50 per cent of water, which doubtless helps to keep the axles cool. It is made more solid for summer than for winter, as it runs more readily in warm weather. In winter it is not always easy to get it to run properly; it is only after the cars supplied with it have traveled several miles, and the journals have become warm, that the grease begins to run, which means, of course, extra work for the locomotive, and consequently extra fuel and oil. Axle grease, in short, is all right as a lubricant "when it gets there."

Australia and Russia are large producers of tallow, millions of sheep being slaughtered every year in Australia for the sake of the tallow alone, the flesh being thrown away or else used as manure; at any rate, this was true until very recently. Now, however, English companies run vessels built with cold-storage chambers and provided with refrigerating apparatus, and the carcasses, all ready dressed, are taken to Europe. This trade by Europe in frozen meat is carried on, for mutton, with New Zealand, Australia, and the Argentine Republic, and, for beef, with the United States, some of the refrigerator vessels carrying many thousands of carcasses at a time. But to return to the main question. The fat is extracted from the tissues, etc., which contain it, by boiling in strong iron vessels, steam at 60 or 70 pounds pressure being used. It is best to boil down the fat—or *render* it, as they say—as soon as possible after the animal is killed, in other words, before decomposition sets in. Immense quantities of tallow and lard are produced in Chicago and other western cities of the United States, the animal parts containing it being put into the boilers a few minutes only after the animal's death. Steam-jacketed vessels are used in this country for the extraction of beef tallow, the temperature being kept pretty low—about 120° to 125° F. (A steam-jacketed boiler, to which reference has been made before, is a double-walled vessel—one vessel inside another, in fact—steam being admitted to the space between the two vessels, thus subjecting the contents of the inner vessel to a dry heat only, without any of the moisture consequent upon the introduction of steam directly into the inner vessel.) In addition to thus procuring tallow from beef and mutton, and lard from the hog, (processes comparatively clean), tallow is also obtained from ship's grease, kitchen truck, etc. These processes are very offensive, and although the products may be good enough for lubricating purposes, it is certainly unpleasant to reflect that they are very often used in the manufacture of oleomargarin, or artificial butter. The more perfect the process of rendering, the less liability there is of the tallow changing chemically, and thus forming acids, which have an injurious effect on metals. Russia produces about 200,000 tons of beef tallow yearly. South America is also a large producer. The western states of America produce large quantities both for home consumption and for export to Europe.

Tallow is also made from the carcasses of old and worn-out horses; a lot of this comes

from South America. Bones are also boiled down for lard, this being, next to the kitchen and ship's-grease trade, about the most offensive trade process known.

Among the semisolid fats with which we are now dealing, we may as well include lard, for it is from an inferior quality of this substance that lard oil is obtained. Lard is extracted from the tissues of the hog, one hog yielding about 35 pounds. When the operation is on a small scale, the lard is extracted by boiling the tissues in open iron vessels over fires, water being added. In the great American factories, steam-jacketed pans are used. The best quality of lard, as used in cooking, is obtained from the fat found around the kidneys; the fat from this and some other parts yields what is known as "leaf" lard, being harder than and superior to the rest; it is drawn off from the vessels while liquid, and run into bladders; the second quality is put into kegs. The next quality is used for making lard oil, and the most inferior, which is made from scraps and trimmings, or parts that have turned rancid, is used for inferior oils or soap making. A large quantity of lard is made in Ireland. Of European countries, Russia produces the most. Hungary supplies a large amount too, the pigs there being fit for little else; about 500,000 are boiled down every year for nothing but the lard they yield. Hog breeding—for lard—is perhaps the chief industry of Servia also. The United States, however, is the greatest producer; we now export annually over 500,000,000 pounds of lard, in addition to our home consumption.

The *butter tree*, grown in West Africa, provides a substitute for butter for cooking purposes. When exported to Europe, it is used in soap making, but the natives use it both for lighting and culinary purposes. If Africa, however, is rich in the possession of her butter tree, China can at least boast of a tallow tree; so, also, can India. The seeds, which yield the fat, are contained in the fruit, and are covered with a layer of fatty material which, when steamed, produces the substance called tallow. The seeds themselves, when crushed and steamed, also yield an oil. The tallow, when cold, is hard and white, and is used by the Chinese for candle making; in India it has been used as a lubricant; it is also suitable for lighting, as it burns freely without either smell or smoke. Java and adjacent islands have also their tallow nuts. In the United States, an oil is extracted from corn, under pressure; it is used in soap making, little being known of its lubricating properties.

Mineral Oils.—Some account will now be given of what is perhaps the most important of the groups into which oils may be divided. Until about the middle of this century, all oils, whether used for lubricating or for lighting, were drawn from the two classes already dealt with; at about that time, Dr. James Young, in England, began to obtain paraffin from oil that he found oozing from a rocky seam in the Midlands, and this paraffin was a light oil that was found to answer very well as an illuminant. Dr. Young also extracted from it a heavy grease, which he used for lubricating purposes. A year or two later, he took out patents for distilling oil from coal at a temperature of about 700° F. Shortly before this, however, another inventor had obtained paraffin from peat. By rapid distillation, the peat yielded a tar which, on being distilled slowly, yielded the oil just mentioned. These discoveries had an immense effect on the oil trade, both lighting and lubricating. At first, these paraffin oils, owing to their poor lubricating properties, were used on light machinery only, and even then they had to be mixed with a certain amount of the richer oils, both animal and vegetable; their large use, in the face of their inferior lubricating properties, has been attributed to their comparatively objectionable smell and taste, which acted as a safeguard against their appropriation by the workmen to their own uses. The writer can quite believe that members of the poorer classes may have found some of the better animal oils rather acceptable for frying, etc., he himself, when out on the road, having often seen a fireman use Russian tallow when cooking his steak or sausage on a shovel. This was in Europe, however.

At the end of the "fifties," petroleum began to be obtained in immense quantities in the United States, and this country began to supply the world with a new kind of illuminant and lubricant. Large quantities of oil are still produced from the bituminous shale found in certain parts of Scotland; this oil is chiefly used in the manufacture of the oil gas used for lighting purposes, being employed in England to make the gas used in the Pintsch system of lighting railroad cars. The use of Russian mineral oils dates back to the year 1700; it was at about that time found welling up from the ground in many places near the Caspian Sea, and was used in its crude state for lighting and other

purposes. The value of these oil-bearing districts was the cause of many struggles between Russia and Persia for their possession. About the year 1800, Russia finally got hold of the territory, in which Baku, the great oil center, is situated, and the trade in mineral oils then fairly began.

Its progress, however, was much retarded, owing to the granting of a monopoly for its working, and this continued until the briskness of the American and Scotch oil trades began to wake people up, and draw attention to the real value of the Russian petroleum industry. Then, in 1872, the monopoly above mentioned was abolished, and, with the inflow of capital and the adoption of systematic and economical methods of working, the Russian oil fields began to grow in importance. Ragosine, a Russian, began to make investigations with a view to producing good lubricating oils to suit the demands of Europe, and his efforts were to a large extent crowned with success. In 1819 it was estimated that Russia was producing 4,000 tons of petroleum yearly. In 1890 she turned out 3,850,000 tons, but America went one better and produced 4,500,000 tons, thus exemplifying in yet another respect the enormous resources of this country.

It is a very pertinent question as to how closely the progress of the world may be allied to the discovery and utilization of mineral oils; this progress has undoubtedly been the outcome of the use of the steam engine; and, bearing in mind the extensive and general use of steam engines of all kinds, and the condition (such as the high temperatures) under which some of them work, it is doubtful whether the earlier sources of lubricating materials would not long ago have proved both insufficient and unsuitable. It seems natural, then, to regard the successive discoveries of the distillation of oil from shale and coal tar, and also the capabilities of petroleum, as matters of immense importance, and also to believe that these mineral oils could not now be dispensed with.

The origin of petroleum has been much debated; it is found in certain geological formations. Some maintain that it is due to decomposition, under extreme conditions of heat and pressure of organic remains, animal or vegetable. Others think that if seawater were to penetrate the earth to very great depths, where the temperature was sufficiently high, it might so act on iron and its sulphides as to form carburets. It is known that volcanic action has given rise to petroleum deposits.

All these oils consist of carbon and hydrogen, and are known to chemists as hydrocarbons. There are, in general use, three ways of obtaining them: (1) From shale oil or crude petroleum by distillation, afterwards washing with sulphuric acid and soda; the oil thus obtained is transparent, varying in color from a pale to a dark amber. (2) By letting crude petroleum settle in tanks, and then filtering it through cotton, canvas, gauze, etc., to remove any grit or other foreign impurities, and then distilling it sufficiently to remove the lighter parts. (3) Oils obtained by methods (1) and (2) are further filtered through animal charcoal, to remove the tar or bitumen, and thus is produced a petroleum jelly sometimes called *vaseline*.

When the mineral-oil industry began, the oils in group (1) had, as a rule, to be largely combined with the richer—that is, more fatty animal or vegetable oils, in order to make them of any value as lubricants; they were also rather thin, or deficient in body, and had a low flash point. American oils, however, showed great improvement in all these respects. At the same time, however, the Russian oils began to improve, evincing not only more "body," but also an ability to withstand very low temperatures without freezing; this latter property being due to the fact that there was no paraffin in their composition; they were also free from one defect the American oils then possessed, namely, that of staining bright metal surfaces.

Class (2) is also divided into two other groups. In the first, the lighter parts, or "fractions," are removed by distillation, as mentioned before, thus concentrating the oil, or *reducing* it, as it is technically termed; this operation is only carried to a certain point, it being arrested when the oil is sufficiently viscous for bearings under ordinary pressures and temperatures. These oils are of a dark color, and are much used where the color is not a matter of importance, such as on railroad cars, etc. In the second kind, the process of reducing is carried still further, increasing the body and raising the flash point to such a degree that the oils thus produced are suitable for cylinders and steam chests.

Class (3) includes oils specially suitable for cylinder lubrication.

The question has often been debated as to whether natural or charcoal-filtered oils are best for cylinders. Now, if we burn a portion of the natural oil, we find after complete combustion that there is a residue of from

3 to 4 per cent. of cinder or coke, and this evidently corresponds to a much greater percentage of tarry matter in the oil originally; on the other hand, the charcoal-filtered oils show only a very minute quantity of coke. So, if we wish to avoid deposits in the cylinder passages, etc., we ought evidently to use charcoal-filtered oils. Every working engineer is familiar with the hard, black, sooty coating that forms in the ports and on the pistons, cylinder heads, etc.; this result is due to the use of such oils as have been previously mentioned.

Solid Lubricants.—Of these, graphite, or plumbago, is the most commonly used; it is a mineral found in different parts of the world. It was first found and worked in Cumberland, England, and chiefly used for making "lead" pencils. Germany also produces it, and it is found, too, in this country and worked in large quantities, the largest factory being in New Jersey. It is almost pure carbon, there being about 99¾ per cent. of that element in it, the remainder being volatile matter and ash. It is a light substance, being but 2¼ times as heavy as water. When properly prepared so as to be free from all grit, etc., it is used as a lubricant for steam cylinders, for which it is well adapted; it is also incorporated in axle grease; and the rope packing so much used for glands has a central core consisting of graphite and tallow, or else soapstone. This *soapstone*, or steatite, is a peculiar mineral substance consisting of silica, magnesia, alumina, and water. It is found in Maryland, Virginia, Vermont, and other states. The clayey earths eaten by some of the South American aborigines are of this nature. It also constitutes the "French chalk" that shoemakers use to make new shoes slip on easily.

There are also bearings made of wood fiber or other substance well mixed with graphite and molded into any required form. The shapes are then thoroughly impregnated with oil (some natural "drier," such as linseed) and then dried. They are then ready for use and require no other lubricant. A substance called *metallin* is sometimes used; this consists largely of graphite, and can be made of any required shape. It is useful for small bushes for light shafts; these require no other lubricant, and when worn, can be slipped out and replaced.

A subsequent article will deal with the general properties—good and bad—of lubricants in general, and will also point out the qualities of individual oils and the class of work for which each is best adapted. An account will also be given of the various tests, mechanical and chemical, necessary to determine the composition and suitability of the various oils, with sketches of the required apparatus.

ALTERNATING CURRENTS.

W. S. Porter, E. E.

ELECTRIC CURRENTS—THE ALTERNATING CURRENT—HOW GENERATED—USE OF ALTERNATE CURRENTS—THE TRANSFORMER.

ELECTRICITY exhibits certain phenomena which can be conveniently compared with the movements of a stream of water through a pipe. Hence, it is said, "The electric current *flows.*" Electric currents are divided into two main classes: *direct currents* and *alternating currents.* A direct current is one which, taking any point in the conductor, flows always in the same direction; for example, the current sent forth from a battery is a direct current. An alternating current is one whose direction of flow constantly reverses, the electricity in the conductor oscillating backward and forward through the line with enormous rapidity, under the influence of a rapidly reversing electromotive force. In addition to the direct current and the alternating current, there is another form, called by some writers the *intermittent current.* For all practical purposes, however, it may be classed with the alternating current. The intermittent current may be derived from the direct current by rapidly making and breaking the circuit, as is done by the vibrator of an electric bell. The action of the intermittent current is much the same as that of the alternating current, and need not be discussed separately.

Perhaps the most simple method of producing an alternating electric current is to

suddenly thrust a permanent magnet (m, Fig. 1) into a closed-wire circuit w, and withdraw it quickly. The entering of the magnet causes a momentary current of electricity

FIG. 1.

to flow through the circuit, the direction of which can be seen by, and the strength measured from, the throw of the galvanometer needle g. The withdrawal of the magnet causes a current of the same strength and duration as the first to flow in an opposite direction, as will be indicated by the swinging of the galvanometer needle.

Every dynamo-electric machine is essentially a generator of alternating current, or, more properly, of an alternating electromotive force, which causes an alternating current to flow. As a coil on the armature of a dynamo passes under a pole, the current induced in that coil flows in a certain direction. When the same coil begins to move under a pole of opposite polarity, the current reverses, and flows in the opposite direction. Fig. 2 represents part of a four-pole machine laid on its side, the armature core A lying between the four poles of alternate polarity; a is a copper rod—one of the conductors with which the armature is to be wound—placed parallel to the axis of rotation, and is supposed to move past the pole s in the direction indicated by the arrow. It will cut the magnetic lines entering that pole, and there will be an electromotive force induced in it which will send a current upwards. Suppose the same conductor to move to the position indicated by c. It will then be moving under a pole of opposite polarity, and the current set up in it would flow downwards. It will thus be seen that the flow is first in one direction, then in the other, alternately upwards and downwards. Now, suppose there were a great many conductors grouped systematically around the core A, as there are in actual machines, and that, every time a current was induced in them by their passage under a pole, it was carried away over an exterior circuit. It is very evident that the impulses that the current in the exterior circuit receives from these conductors, are alternately positive and negative, as the conductors pass under a positive or negative pole.

Sometimes, it is desirable to have the current in the exterior circuit flow continuously in one direction, particularly if the machine is to furnish electricity to run motors. When a direct-current dynamo is desired, it is only necessary to equip the machine with a *commutator*—a device to rectify the alternating character of the current, that is, to alternately connect each conductor to one terminal then to the other terminal of the exterior circuit as often as the current in the conductor reverses. In this way the current in the exterior circuit is made to flow continuously in one direction.

With alternating-current machines there is no need of a commutator; but, in general, these machines have to be provided with some device for making a *sliding* connection. For, in those forms in which the armature rotates, its coils must be brought into continuous metallic contact with the conductors

FIG. 2.

of the main, or exterior, circuit. In those forms in which the armature is stationary, no such arrangement is needed at that part, but there must still be sliding contacts to maintain the coils of the revolving field magnets in continuous metallic contact with the auxiliary exciting circuit. In either case an appropriate device consists of a pair of collecting rings, against each of which a

brush presses. The usual manner of arranging the collecting device is shown in Fig. 3. Two undivided insulated metal rings, forming the terminals of the armature coils, slide

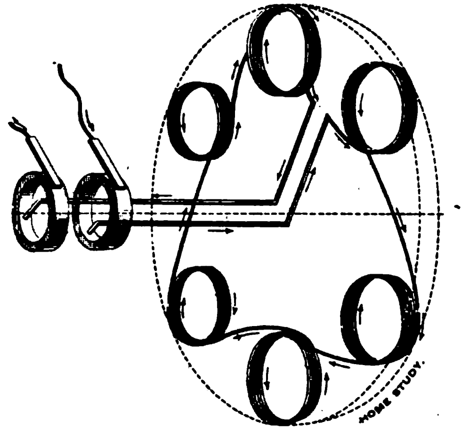


FIG. 3.

each under a single collecting brush. These brushes form the terminals of the main circuit.

Where electric power is to be carried a long distance over wires, it is desirable to use as small a wire as possible, in order that the expense for copper shall be light. To use small wire, the current must be transmitted at high voltage and low amperage. But in the high-voltage form the current is dangerous to handle and its application is difficult, especially for lighting purposes, and it must therefore be transformed to low voltage and high amperage. Now, since the alternating current may be transformed very cheaply as compared with the direct current, it is preferable to use the alternating current wherever it can be used. That is why the alternating current is used so extensively for commercial lighting purposes.

The apparatus used for transforming electric power is called a *transformer*. Fig. 4 is an illustration of an alternating-current transformer in its simplest form, and from it may be gathered a knowledge of the underlying principles of the transformation of electrical energy. From a study of Fig. 1 we saw that a momentary current would be set up in a coil by moving a magnet through it. Conversely, if a momentary current be sent through a coil, such as $P\,P$, Fig. 4, a magnetic impulse will be created in the soft-iron core C, which is surrounded by $P\,P$. In turn, the magnetic impulse will cause a momentary current in the coil $S\,S$, which also surrounds the core C. The strength of the current, or electromotive force, in $S\,S$ will be, in proportion to that impressed upon $P\,P$, as the number of turns in $S\,S$ is to the number of turns in $P\,P$. Now, suppose $P\,P$ to have 100 turns of wire around the core, while $S\,S$ has but 10. This would mean that the voltage of the induced electromotive force in $S\,S$ would be $\frac{10}{100} = \frac{1}{10}$ of that impressed upon the primary $P\,P$. A transformer in which the induced voltage is less than the impressed is called a *step-down* transformer, and one in which the induced is greater than the impressed electromotive force is called a *step-up* transformer. By sending an alternating current through $P\,P$, the action of a momentary current is repeated every time the current reverses, which is many times a second, making the action of the transformer continuous.

It has been stated here that the direct current is preferable for power purposes. Up to very recently, such has been the case, owing to the difficulties encountered in making an alternating-current motor that

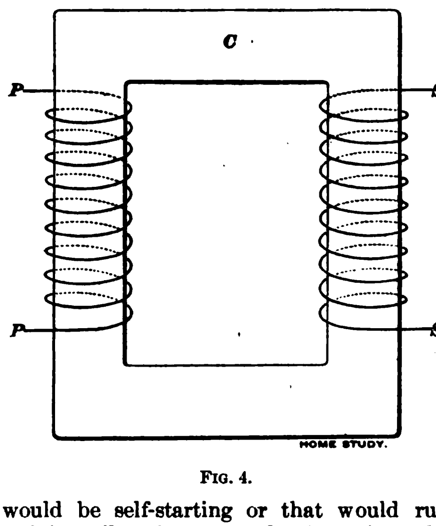


FIG. 4.

would be self-starting or that would run satisfactorily when started. But, since the perfection of the induction motor and polyphase motors and generators, the alternating current has been gaining a place for power purposes.

THE GRAPHICAL REPRESENTATION OF EQUATIONS.

Benj. F. La Rue.

RECTANGULAR COORDINATES—THE LOCUS OF A POINT—RECTANGULAR AXES—ABSCISSA AND ORDINATE—PRACTICAL CURVES.

THE value of plane loci, or "curves," as they are commonly called, both for representing graphically the values of working formulas, and for deriving the formulas from experimental conditions, is being more and more recognized in engineering practice. The curves are of especial value in experimental engineering. This subject of mathematics forms a special branch of Analytical Geometry; it is not only of much practical importance, but is very interesting, and easily understood.

The *locus* of a point is the line or geometrical figure generated by the point when in motion according to some fixed law. The locus, or path of the point, may be either straight or variously curved; but, whether straight or curved, it is not uncommonly spoken of as a *curve*.

The loci of points may be represented by, and constructed from, equations by referring them to lines or axes having known positions. The method commonly used for constructing the loci of engineering formulas employs axes at right angles to each other, and is known as the *method of rectangular coordinates*. It is also called the *Cartesian method*, because it was originated by Des Cartes, the famous French mathematician. This method will be here explained. All points and lines here referred to will be understood to lie in the same plane, which, for convenience, will be considered to be the plane of the paper.

If two straight lines of indefinite length be so drawn as to intersect each other, the position of any point in the plane of the lines may be located by its respective distances from the lines.

The two intersecting lines become lines (axes) of reference, and any point may be located by its position with reference to the lines in the same general manner that the position of a point on the earth's surface may be located by its latitude, reckoned from the equator, and its longitude, reckoned from a given meridian. These lines of reference, or axes, are usually drawn at right angles to each other.

In Fig. 1, XX' and YY' are two straight lines intersecting each other at right angles in the point O. Both lines are assumed to be fixed in position, and of indefinite length. These lines are called *axes of reference* or simply *axes;* when they intersect at right angles, as in the present case, they are often called *rectangular axes*, in order to define the manner of their intersection. The horizontal axis XX', is called the *axis of abscissas* or *axis of* X, and the other axis, the *axis of ordinates* or axis of Y. The point of intersection O of the two axes is called the *origin*.

The position of any point in the plane, as the point P, may be located by its respective directions and distances from the two axes.

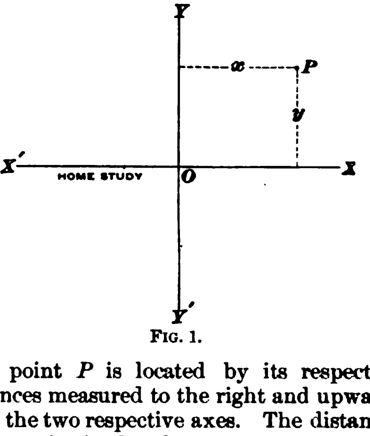


FIG. 1.

The point P is located by its respective distances measured to the right and upward, from the two respective axes. The distances of any point in the plane from the two axes, when both distances are considered, are called the *coordinates* of the point.

The *abscissa* of a point is its distance from the axis of ordinates, measured parallel to or along the axis of abscissas; as here used, it is the horizontal distance of the given point to the right or left of the axis of ordinates. In Fig. 1, x is the abscissa of the point P.

The *ordinate* of a point is its distance from the axis of abscissas, measured parallel to or along the axis of ordinates; as here used, it is the vertical distance of the given point above or below the axis of abscissas. In

Fig. 1, y is the ordinate of the point P. When using rectangular axes, it is customary to lay off the abscissa along the axis of abscissas, and then lay off the ordinate perpendicularly above or below the point thus located on the axis of abscissas. In the usual notation, the abscissa of a point is represented by the letter x and the ordinate by y.

Of the four angles formed by the intersection of the axes, that above the axis of

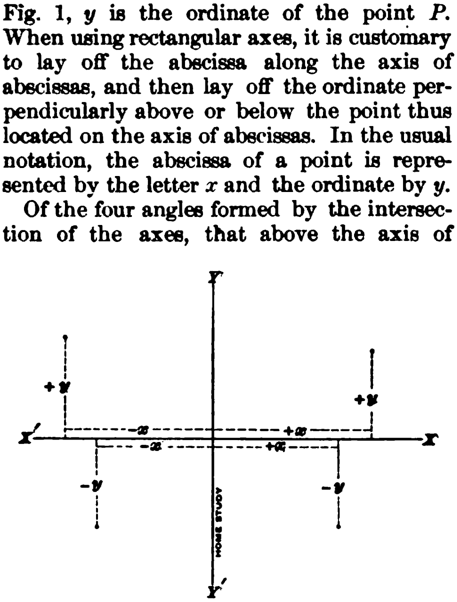


FIG. 2.

abscissas and to the right of the axis of ordinates, or $X\,O\,Y$, is called the *first angle;* that above the axis of abscissas and to the left of the axis of ordinates, or $Y\,O\,X'$, is called the *second angle;* that below the axis of abscissas and to the left of the axis of ordinates, or $X'\,O\,Y'$, is called the *third angle;* while the angle below the axis of abscissas and to the right of the axis of ordinates, or $Y'\,O\,X$, is called the *fourth angle.*

In order to indicate in which of the four angles a point is situated, abscissas measured to the right from the axis of ordinates are considered + and those measured to the left are considered — ; while the ordinates measured upwards from the axis of abscissas are considered + and those measured downwards are considered —. Hence, in the first angle, the sign of both abscissa and ordinate is + ; in the second angle, the abscissa is — and the ordinate + ; in the third angle, both abscissa and ordinate are — ; while in the fourth angle the abscissa is + and the ordinate —. This is clearly shown in Fig 2.

When the coordinates of a point are known, the point may be readily located, as follows :

On the axis of abscissas, lay off, to any convenient scale, a distance from the origin equal to the given abscissa ; it must be laid off to the right if + and to the left if —.

From the point on the axis of abscissas thus located, lay off, to any scale, a vertical distance equal to the given ordinate, upwards if + and downwards if —. The point thus located at the extremity of the ordinate will be the required point.

Two kinds of quantities are used in equations expressing loci or curves ; namely, constant and variable.

Constant quantities always have the same values in the same equations ; they are usually represented by the leading letters of the alphabet.

Variable quantities may assume any values within the limits established by the nature of the equation ; they are represented by the final letters of the alphabet.

Constant and variable quantities, as here used, should not be confused with the known and unknown quantities of algebra. There is no similarity except in the notation employed. Constant and variable quantities, or variable quantities only, may be combined in the form of an equation to express the locus of a point. Such an equation is called the *equation of a locus* or the *equation of a curve.*

Construction of Curves.— To construct a curve, or locus, is to construct the geometrical figure representing a given equation. This is done by locating a sufficient number of points in the locus by their coordinates so that the locus may be drawn through them. The coordinates of a point may be determined from an equation by assuming any convenient value for one variable, and then solving the equation for the corresponding value of the other variable. In order to distinguish them, the variable to which a value

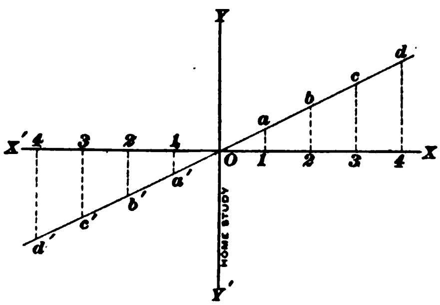


FIG. 3.

is arbitrarily assigned is called the *independent variable* and the other is called the *dependent variable.* The abscissa x is commonly taken as the independent variable. If the value found for the dependent variable is *real,* the values of the two variables will be the required coordinates of the point. But if the value obtained for the dependent

variable is an imaginary quantity (i. e., an even root of a negative quantity), it will indicate that for that particular value of the independent variable, the value of the dependent variable cannot be represented. Consequently, another value must be assumed for the independent variable, and the equation solved again.

The method of procedure in constructing

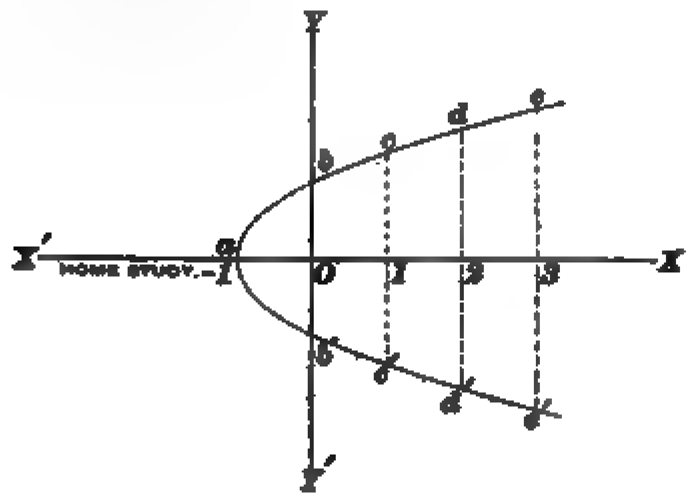


FIG. 4.

an equation may be stated by the following:

RULE.—*Transpose the equation to a form expressing the value of either variable. Consider this as the dependent variable. Assign a value to the other or independent variable, and, by substituting it in the equation, find the corresponding value of the dependent variable. If the value thus found for the dependent variable is a real quantity, locate a point in the locus by using the values of the two variables as coordinates. By repeating the process, locate a sufficient number of points so that the locus can be drawn correctly through them.*

EXAMPLE.—Construct the equation $x = 2y$.

SOLUTION.—By transposing to the form $y = \frac{x}{2}$ and substituting successive values for x, we obtain the following values for y:

When $x = 0$, $y = 0$ (O)
When $x = 1$, $y = \frac{1}{2}$ (a)
When $x = 2$, $y = 1$ (b)
When $x = 3$, $y = 1\frac{1}{2}$ (c)
When $x = 4$, $y = 2$ (d)
When $x = -1$, $y = -\frac{1}{2}$ (a')
When $x = -2$, $y = -1$ (b')
When $x = -3$, $y = -1\frac{1}{2}$ (c')
When $x = -4$, $y = -2$ (d')
etc., etc.

By locating the points fixed by the coordinates thus determined, the locus $d\,d'$, Fig. 3, is obtained. The condition that $y = 0$ when $x = 0$ shows that the locus passes through the origin. When $x = 1$, we measure a distance of one unit to the right of the origin, along the axis of abscissas, locating the point 1. For this value of x, $y = \frac{1}{2}$; hence, we measure upward from the point 1, as located on the axis of abscissas, a distance of one-half unit, locating the point a on the locus. Each of the points $b\,c\,d\,a'\,b'\,c'$ and d' are located in a similar manner. It is found that the line passing through all these points and through the origin is a straight line. In locating the points, any convenient scale may be used to represent the values of the variables, so long as the same scale is used for all abscissas and the same scale for all ordinates. It is evident that in the present case *any* value substituted for x will give a real value for y; this indicates that the locus extends indefinitely in either direction.

EXAMPLE.—Construct the equation $x = y^2 - 1$.

SOLUTION.—If, in this equation, we substitute the value $y = 0$, then $x = -1$. We also notice that for any negative value of y, x has the same value as for a positive value of y. By transposing and solving for y, we get

$$y = \pm\sqrt{x+1},$$

and, by substituting successive values of x, beginning with -1, we obtain the following values of y:

When $x = -1$, $y = 0$. (a)
When $x = 0$, $y = \pm\sqrt{1} =$ 1.00 (b) and -1.00 (b')
When $x = 1$, $y = \pm\sqrt{2} =$ 1.41 (c) and -1.41 (c')
When $x = 2$, $y = \pm\sqrt{3} =$ 1.73 (d) and -1.73 (d')
When $x = 3$, $y = \pm\sqrt{4} =$ 2.00 (e) and -2.00 (e')

Any negative value of x numerically greater than -1 will give an imaginary quantity for y. For instance, if $x = -2$, $y = \pm\sqrt{-1}$,

FIG. 5.

showing that no point on the locus can have this value of x. By locating the points fixed by these coordinates, the locus $e\,a\,e'$, Fig. 4, is obtained. The process will be readily understood. The locus is found to be a parabolic curve not passing through the

origin. If the equation were simply $x = y^2$, the parabola would pass through the origin.

The examples given will suffice to explain the general method of constructing equations. In ordinary engineering formulas, both variables have positive values. Hence, such equations are constructed in the first angle only. For such constructions, the axis of abscissas is taken at the lower edge, and the axis of ordinates at the left-hand edge, of the diagram. The origin, therefore, will be at the lower left-hand corner of the diagram.

In order to facilitate the construction of equations, in engineering practice, a specially ruled paper, known as *cross-section paper*, is used. This paper is lightly ruled in small squares and, in order that the lines may be easily counted, each tenth line is ruled heavier. By considering each ruled division of the paper equal to one unit, ten units or any convenient number of units, an equation can be quickly constructed.

EXAMPLE.—Professor Johnson's formula for the ultimate strength, in pounds per square inch, of flat-ended white pine columns, whose lengths do not exceed 60 diameters, is

$$p = 2{,}500 - 0.6\left(\frac{l}{d}\right)^2.$$

Construct the equation.

SOLUTION.—If we substitute y for p and x for $\frac{l}{d}$, we have the equation $y = 2{,}500 - 0.6x^2$. By assigning successive values to x, the following values of y are obtained:

When $x = 0$, $y = 2{,}500$
When $x = 10$, $y = 2{,}440$
When $x = 20$, $y = 2{,}260$
When $x = 30$, $y = 1{,}960$
When $x = 40$, $y = 1{,}540$
When $x = 50$, $y = 1{,}000$
When $x = 60$, $y = 340$

The locus or curve for this equation is shown in Fig. 5. The construction will be readily understood and will require no special explanation. It will illustrate the construction of a diagram giving the values of an ordinary working formula. It will be noticed that for any value of $\frac{l}{d}$ (length divided by diameter) the value of p may be at once read from the diagram with sufficient accuracy for all practical purposes.

WATER COOLERS.

Thomas N. Thomson.

NECESSITY OF DRINKING FREELY DURING HOT WEATHER—SOME PEOPLE DRINK DISEASE-BREEDING ICE WATER—COOLERS BUILT ON WRONG PRINCIPLES—HYGIENIC COOLERS.

DURING the hot season, when the thermometer indicates some 90° in the shade, we are all prone to drink, and drink we *must*, in order to compensate for the large amount of water that is being invisibly and imperceptibly evaporated from our bodies. If we do not drink freely while running the gauntlet of Old Sol's impartial rays, we will soon not only become mere shadows of our former selves, but run the risk of contracting the maladies peculiar to dwellers in hot, dry climates, such, for example, as kidney disease and dropsy.

It must be understood that in our bodies a combustion of the blood is constantly going on, similar in some respects to the combustion of coal in a furnace, though much more slowly, and, of course, with less intensity of heat. While the combustion of coal is accompanied by certain products known as ash, which must be removed to prevent the air supply to the fuel from being choked off, so also is the combustion of the blood accompanied by waste products, which must be diluted and made capable of being removed from the kidneys to prevent these from becoming conjested and choked, if we may use the expression.

Uric acid is one of the products which, from a mechanical point of view, may be called the ash of the blood; and the kidneys are the ash-pit. If this ash-pit is not cleaned out, it will surely fill up like any other ash-pit, and thereby smother the fire that filled it. It is the duty of all human beings to clean out their own ash-pits, which can best be accomplished by drinking copiously of wholesome water; this will dilute the uric acid and compel it to flow away through the proper channels. Nature has provided us with a sense of thirst, and woe betide the man who does not drink when he is thirsty.

We are all more or less interested in our own organisms, so perhaps it will not be out of place here to give a little thought to the damage that may be done by neglecting the requirements of the body and the demands of thirst. To more thoroughly comprehend the function of the kidneys, let us refer to them as filters, for that is what they really are, their duty being to filter the urine out of the venous blood. If the uric acid is not properly diluted, and the kidneys are not kept clear, the uric acid will back up into and become secreted by the flesh, thus tending to produce dropsy, Bright's disease, or paralysis of the heart; in fact, some physicians claim that the great mortality during winter is largely due to the injury done to the kidneys, brain, and heart, during summer.

FIG. 1.

When the uric acid becomes too dense, certain concretions are formed in consequence of the deposition, in solid form, of matters which usually remain in solution; these are known in pathology as *calculi*. Urinary calculi, although capable of being formed in either man or woman of any age, are much more common in elderly men, who, therefore, should, in warm weather, drink copiously of water. The chief varieties of urinary calculi consist of urates of ammonia, soda, lime, etc., phosphates of ammonia and magnesia, lime, etc., and carbonate and oxalate of lime, etc.

Calculi, or stones in the kidneys and bladder, are often composed of numerous successive layers, each layer appearing to have a chemical composition distinctly different from the others; such stones are called *alternating calculi*. Fig 1 represents a stone of this kind that was described by Dr. Marcet in an essay on calculi. The central part *a* is a uric-acid nucleus, or gathering point, over which a mass of oxalate of lime *b* became concreted. A deposit of phosphates of lime, magnesia, and ammonia *c* has become concreted to *b*, and the whole mass constitutes a calculus, or stone, that doubtless caused much suffering to the unfortunate owner. We, therefore, should drink freely, and thus dilute the uric acid before the matter in solution has become subject to deposition.

Now, the problem resolves itself into the question "What shall we drink?" The answer is, water — wholesome, palatable water; for it is both the cheapest and the best of drinks. If we had to pay five cents a "schooner" for it, each of us would spend at least twenty-five cents a day during the summer on this greatest of all thirst quenchers, and even then would probably try hard to get "six drinks for a quarter." Fortunately, in nearly all inhabited parts of the civilized world we can easily and at any time get a drink of water free of charge, for which glorious privilege we should be exceedingly thankful. The thirsty "scorcher" on his wheel should not keep on scorching or wait until he returns home or arrives at a wayside inn before getting a drink; he should dismount at the first house he comes to, cool off a little, if necessary, and then ask for a drink of water that is not too cold. The bashful young man and his best girl when out buggy riding should lay aside their bashfulness and stop at the farmhouse to sip from the "old oaken bucket" when their throats are parched. In fact, any sensible girl would be justified in forgetting a fellow who, "with a thirst on," would pass such a bucket.

FIG. 2.

Nowadays, nearly all railroad stations,

public buildings, large stores, and commercial buildings are furnished with accessible water tanks or fountains, where any one may quench his thirst. But though all these things are nice, there is danger in many of them. Of course, most of the water thus supplied is cooled with ice during the hot summer weather, and that is perfectly proper, because there are few drinks more distasteful than warm water, particularly when drawn from a tank that has "ice water" indelibly stamped on its face. The danger referred to lies in the fact that the ice employed to cool the water is melted *in the water*, so that the people who drink the water actually drink the ice with it. If the ice is perfectly pure, there is no harm done; but it is seldom pure, being as seldom harvested from the surfaces of pure, fresh-water lakes or rivers. Many thousands of tons of ice are annually cut and gathered in from sewage-polluted rivers, and from lakes which are literally thick with animalcules and foul with organic matter.

If the kind people who so benevolently and with such good intentions furnish ice water for the public knew what a microscopical examination of impure ice would reveal, it is certain they would immediately purchase pure artificial ice or throw the old coolers away, for it is certainly not the intention of these good people to injure their fellow men by inducing them to drink melted ice laden with such germs and contaminated with organic poisons.

The improvement required in common water coolers is very simple and inexpensive, and the manufacturers of water coolers are only too pleased to cater to the wants of the people when the people proclaim their wants.

What is needed is a water cooler in which the melted ice can be removed, or run to waste, and in which the drinking water will be cooled but not polluted. A simple cooler which any tinsmith can make is shown in Fig. 2, consisting of an ice chamber *a* open at the top and screwed on a waste pipe at the bottom. A drinking-water chamber *b* surrounds the ice chamber, and the water here is cooled by contact with the cold chamber. An insulating chamber *c* surrounds the water chamber and prevents the water from being too rapidly warmed by the outer air. A valve *d* may be opened to drain away the melted ice.

This, then, is one form of hygienic water cooler; there are many others, and it behooves the public to use water coolers of this class only.

Regarding the proper temperature of ice water for drinking purposes, it is generally conceded that from 45° to 50° F. is the most healthful range consistent with palatableness. Drinking waters at temperatures higher than 50° F. are not so palatable, while those at a temperature lower than 45° F. are considered too cold for safe copious drafts. The lowest temperature which is ordinarily obtained by putting ice into water in a thin glass tumbler is about 35° F.; in a thick glass tumbler or porcelain pitcher, about 34° F.

PHOTOGRAPHY FOR AMATEURS.

George F. Lord.

THEORY OF PHOTOGRAPHIC PRINTING—MAT SURFACE PAPER—SILVER PAPER—MOUNTING. GLAZING—TRANSPARENCIES—HOME-MADE FRAMES.

IT WILL be remembered that on the negative, all the dark or opaque parts represent light parts in the object or scene photographed. That is why it is called a negative. In printing, we merely proceed to make a positive from this negative, which will again present the degrees of light and shade that existed in the original. The reproduction of the colors of the object has never been accomplished practically, so we must content ourselves—at least for the present—with producing monotone, or single color, prints. These may be produced in many colors—blue, black, brown, green, purple, and reddish tones being obtained, according to the kind of printing paper used. There are many varieties of printing paper, but those that are most popular with amateurs are but three in number, and are "blue paper," "silver paper," and "bromide paper."

Blue Paper.—This is by far the easiest to

handle, so we will deal with it first. Prints made with it are called *blue prints*, the lights and shades in the picture being different depths of a very rich blue color. Blue paper can be prepared by the amateur himself; but it costs very little to buy, and as fresh, evenly coated paper is easily obtainable, we think it will be found more satisfactory to buy it.

No paper should be bought in larger quantities than is required for early use, as all varieties deteriorate with age. If the paper is bought in large sheets, it should be cut in a subdued light, to the size of the negative used, care being taken to avoid wetting the prepared surface.

In printing, a negative is placed in the printing frame, glass side outwards. Then a piece of sensitized paper is laid with its sensitive surface against the film side of the negative, and the back of the frame secured in place. The frame should now be placed in a strong light to print. Sunlight is not always desirable, especially if the negative is thin. But it is well to make the first print in the sun. The light falling on the negative passes through the transparent parts, and darkens the paper, but is restrained by the opaque parts, and thus does not act chemically on the paper underneath such parts. After a few minutes' exposure the frame may be removed to a subdued light (indoors) and the print examined. The back of the holder is hinged, and each hinged part is held down by a spring. To examine the print, one spring is loosened and the hinged part lifted. One end of the paper may then be turned back without disturbing its position on the negative. When done, the parts most affected by the light will present a metallic, bronzed appearance, but the details of the picture do not appear very sharply. Some experience is necessary to enable one to tell just when the print is done. In a strong sunlight, a good negative should print in from 3 to 4 minutes. The print is developed by placing it in a bath of cold water, face down. Any bubbles which adhere to the surface should be broken up. A yellowish deposit will fall from the print, leaving the light parts a clear, bluish white, and the dark parts a rich blue.

After washing the print for about 15 minutes, in several changes of water, it is allowed to dry between blotters or is suspended by a pin on the wall. We have found that a fine finish may be imparted to a blue print by ironing it while it is still damp—using a hot flatiron on an ordinary ironing board. This prevents any tendency to cockling and effects a decided improvement in the appearance of the print.

Silver Paper.—By this name is meant all papers that are sensitized with chloride of silver, held in position either in gelatine or collodion. The former is the favorite among amateurs, as being somewhat easier to work, so we will confine our attention to that variety. It is sold in packages of either one dozen or one gross sheets, cut to standard sizes. Being very sensitive to white light, the package should be opened in a subdued light indoors, and when a sheet has been removed, the rest should be replaced in the package as quickly as possible.

The actual operation of printing is similar to that already described in reference to blue paper, and here again experience alone will tell just when to stop printing; this much may be said, however: printing must be allowed to proceed until the color is much deeper than that desired when the picture is finished, as it loses depth in the washing and toning processes. On removal from the frame the color of the print is found to be a reddish brown, not at all a pleasant shade. To obtain the color desired, the operation of *toning* has to be performed. Before this can be done, however, the print must be thoroughly washed in many changes of water, or in running water, for about one hour. The washing removes the soluble silver in the gelatine, and must be very thoroughly done, otherwise the final color of the picture, after toning and fixing, will be unsatisfactory.

The toning process consists of depositing gold upon the surface of the print. Gold for toning is sold in little bottles containing 15 grains. This quantity must be dissolved in 15 ounces of water and put in a bottle, and kept in the dark. The 15-ounce bottle constitutes what amateurs generally call their *stock toning solution*—one grain of gold per ounce of water. To use, take a porcelain dish—a perfectly clean one, kept for this purpose and used for no other—and pour into it 4 ounces of water; into this put 40 drops of the toning solution. (The correct proportion is 25 ounces of water to 1 ounce of solution, but as this is a larger quantity than the beginner requires for toning his first picture, the above quantities, which are about right, are given). Now drop into the dish a piece of red litmus paper and add sufficient saturated solution of borax to make this paper turn pale blue. Previous to the addition of the borax, the bath was acid; the borax changes it to alkaline, and as an acid

bath will not tone a picture, the operation is very necessary. The bath being ready, place the print in it and keep the dish moving, so that the toning will take place evenly over the entire surface. At first, no change is noticeable, but soon the brown color begins to get richer, then changes to purple. Stop toning when there is rather more brown in the color than you like, as this will be lost in the fixing.

The fixing bath is as follows :

Water	30 ounces
Hypo	1 ounce
Alum	½ ounce

This should be prepared before beginning to tone, so as to be ready. Pass the toned print through a couple of changes of water (or wash in running water for a few seconds); then place it in the fixing bath for 15 minutes, rocking the tray every moment of the time. If the fixing solution is not kept in motion, the print will have a "mealy" appearance.

After fixing, the prints must be washed either in running water or through many changes, for half an hour, to remove every trace of the hypo from the paper and gelatine.

Bromide Paper.—Bromide printing can be done at night, and is, therefore, popular with amateurs, who are generally occupied at business during the day time. Bromide paper is covered with a solution of bromide of silver, similar, in fact, to that used on the plate for making the negative, except that it is much slower acting; that is, requires longer exposure. There are various grades of this paper, and it is made with either a glossy or a dull surface; the latter kind is generally called *mat-surface* paper. All kinds must be handled in ruby light, being, like the negative plates, sensitive to other colors. To print with bromide paper, place in the frame as already described, and expose to the light of a gas burner or lamp. Choose some convenient distance from the light and always print from the same place, so that when once you have discovered the proper time for exposure you may have no more guessing to do.

The mat-surface papers are especially good for landscapes, as they give a softness to the picture that is very pleasing. Instructions for the development of bromide papers accompany every package, and are so complete that nothing need here be said of the operation, varying slightly, as it does, with the different grades of paper sold.

Mounting the Prints.—Before mounting the prints, they should be trimmed to the desired shape and size. The paste used is made of starch, as follows: Dissolve one teaspoonful of common starch in a little cold water in a tea cup. Then add enough boiling water to nearly fill the cup, and stir the mixture. It rapidly thickens and is ready for use when cool. It should be applied with a brush or swab of cloth to the back of the print, and well rubbed in. The print is then laid in position on the mount, covered with a soft, clean sheet of paper, and rolled down. Any superfluous starch which may be squeezed out can be wiped off with a clean cloth without injury to the mount. In mounting silver prints, the process is somewhat different. On account of its prepared surface, a beautiful polish may be imparted to it. The professional does this with his burnisher, after the print is mounted, but the amateur may do very well with a ferrotype tin. This can be purchased at any photographic supply store for a few cents. One side of this tin is highly polished. If the silver prints are taken from the final washing, placed face downwards on the polished surface and rolled or pressed firmly against it, they will adhere. As the moisture evaporates, the paper peels off, leaving a brilliant polish on the surface of the paper. If care is used, in mounting, not to allow any moisture to get on the surface, this gloss may be retained.

Aside from the processes described, there is another method of obtaining positives which is very interesting, namely: transparencies on glass. For this purpose, a slow dry-plate is desirable and a negative having good contrasts. The operation is very simple. The negative and a printing frame are taken into the dark room and the red lamp lit. Then a mat of any desired shape, made from opaque paper, is placed in the printing frame, then the negative, film side upwards, then the plate, with the film side down, and finally a piece of dark paper to prevent reflection. The back of the frame is then clamped in position. Holding the frame perpendicularly about 15 inches from the red light, the slide is quickly raised, and the rays allowed to fall on the plate for about 5 seconds (more or less, according to the density of the negative and the speed of the plate). The plate is developed in the ordinary way, a transparent positive resulting, which may be mounted in contact with a ground glass, and hung in the window, the two sheets of glass being held together by black cotton edging, pasted on.

Lantern slides are transparencies made as above, and are either colored or left black and white.

THE STUDY OF INSECT LIFE.*

Adam Kaufman.

STUDY OF ECONOMIC ENTOMOLOGY—BREEDING CAGES OF VARIOUS KINDS—PRESERVATION OF BIOLOGICAL SPECIMENS—THE INFLATING PROCESS.

THAT branch of applied science which treats of the habits of insects and the best means of destroying those that are in any way injurious to human interests, is known as *economic entomology*.

The number of injurious insects in the United States is large, and is increasing. The most obnoxious of them, among which are the wheat-midge, Hessian fly, grain aphis, coddling moth, cabbage butterfly, and clover-root borer, have been accidentally brought over from Europe. Owing to the destructiveness of these introduced species, large areas devoted to special crops—particularly in the more recently settled parts of the country—are liable to insect depredations.

It is estimated that the value of the agricultural products of the United States amounts annually to about three thousand million dollars; of this, about one-twentieth, or one hundred and fifty million dollars' worth, is lost every year in consequence of the ravages of insects. Plants, especially those of general cultivation, afford subsistence to many species of insects which prior to the settlement of this country lived on plants of other kinds. The insects of the apple and other fruit trees, before those trees were introduced into America, lived on certain forest-trees, such as elm, oak, ash, wild cherry, poplar, and willow.

The philosophic study of entomology requires much more than the mere collecting of specimens, one of the most profitable as well as the most fascinating phases of the study, relates to the life-history and habits of insects. There is no branch of natural history in which biological studies are more easily carried on, or in which the biologic facts are more remarkable or interesting. It is rarely practicable to watch the development of an individual insect in the field, but in confinement many facts relating to its life history can be obtained. In collecting insects for studying and rearing in confinement, careful observation must be made of the conditions under which the insects naturally live, in such matters, for instance, as temperature, moisture, food supply, and conditions for pupation, the value of final results depending upon the accuracy of these observations. Great care should be taken not to injure the specimens when collecting.

The transformations of a great number of insects, terrestrial as well as aquatic, can be studied only by careful outdoor observation. But the majority of insect larvæ may be reared indoors, and their maneuverings may be carefully and constantly watched. For the feeding of small species, glass jars and wide-mouthed bottles will be found useful. The mouths should be covered with gauze or muslin, fastened by tying a string around the neck of the bottle. A few inches of moist earth should be placed in the jar, to keep the air in the jar moist, and to furnish a retreat for those larvæ which enter it to transform.

A very simple breeding cage is shown in Fig. 21. It consists of an ordinary box, say 10 inches long, 6 inches wide, and 12 inches deep, or any other convenient size. The sides of the box are taken off, except a narrow piece *a* on each side; these should be about 4 inches high, to retain a layer of soil in the bottom of the cage. A narrow board *b* is nailed to the top of the front side of the box, and across the opening on the other side at *d* a fine wire gauze is fastened. A piece of glass *c* should fit closely across the front, to prevent the escape of insects; this can be made to slide and serve as a door if the edges *ee* of the front boards *a b* are beveled.

FIG. 21.

In rearing leaf-eating larvæ, such as caterpillars, branches of their food plant should be placed in the bottom of the box, or stuck in a wide-mouthed bottle filled with water,

* *Continued from September, 1898, Number.*

and a sponge placed around the stem of the branch, to prevent the larvae from drowning; it is a good plan to use moist sand instead of water.

This form of cage admits abundant light and air, and also permits the easy removal of excrement, which falls to the bottom. The insects, in transforming, enter the ground or

(a) *(b)*

FIG. 22.

attach themselves to the sides or top of the cage, according to their habits.

The soil surrounding the bottle at the bottom of the cage should be kept constantly moistened, though not too much so, or the soil will become solid and moldy. In winter, when insect life is dormant, the soil should be covered with clean damp moss, as a large proportion of insects pass the winter in the pupal state.

Hibernating pupæ may be left in the breeding cage or removed and packed in moss, in small boxes. The cages or boxes may be put away in a cool cellar, where only occasional inspection is necessary, but nevertheless the moss must be kept damp. If hibernating pupæ are kept in a warm room during the winter, they are apt to emerge before spring.

The breeding of many insects can be done with much simpler apparatus than the above. The food plant of the insects to be bred may be planted in a flower pot; or, in the soil of the flower pot can be inserted a bottle filled with moist sand, and stems of the food plant stuck into the sand; over the plant may be placed a lamp chimney, Fig. 22, (*a*), the top of which should be covered by a piece of muslin or mosquito netting. For large plants a fruit jar with the bottom broken off, Fig. 22 (*b*), may be used in place of the lamp chimney. The bottom may easily be broken off in the following manner: Scratch a mark with the edge of a file or other hard, sharp instrument, around the circumference of the jar where you want it to break; then revolve the jar over the flame of a lamp, heating it along the scratched mark; this will cause it to break where required; if it does not crack readily, a little cold water dropped on the heated mark will start it.

An important thing to remember with larvæ in jars is to thoroughly wash out the jars every day with cold water. If, however, a caterpillar has spun a web on the side and is hanging up to molt, it must not be disturbed. In changing the food it is better not to remove the caterpillar from the old food, but to drop it with the piece of leaf upon which it feeds into the jar, after putting in the new food. Regular notes should be written on a piece of paper attached to the cage or jar. These notes should give the dates of every noticeable feature, particularly the dates of the molts and the changes that take place in the form and color of the specimen.

For the outdoor rearing of caterpillars from the egg, a very simple cage may be constructed by bending two wires U-shaped and pushing them into the ground so as to form two arches, as in Fig. 23 (*a*). The arches are then covered with gauze, the edges of which may be kept down by placing earth upon them; care should be taken that the leaves of the plant inside the net, such as clover, etc., are fresh and in a natural position. The female butterfly or moth may be placed in this cage, and the eggs which it lays gathered from time to time and placed in the regular breeding cage; here the larvæ, when they hatch, may be constantly supplied with their natural food plant. For species which oviposit on large trees or plants, the female may be placed in an inclosed bag made of mosquito netting, and tied over a branch, as in Fig. 23 (*b*).

(b)

(a)

FIG. 23.

A pupæ box, for the rearing of butterflies and moths from pupæ, is shown in Fig. 24. It consists of a box about 18 inches long,

8 inches wide and 10 inches deep, a drawer *a* being placed in the bottom, a wire gauze *c* fastened across the inside a little above the drawer, and a piece of glass fastened with narrow strips to the hinged cover. The pupæ are placed between layers of moss *d*, and water is kept in a saucer *e* placed in the drawer; by this means the moss may be kept

FIG. 24.

uniformly damp. In spring, the insect emerges from the pupa and climbs up the side of the case, from where it may be taken, after its wings are dry, and placed in the cyanide bottle to be killed. It is then ready to be spread for the cabinet.

There are a great many root-inhabiting insects such as the chinch bugs, cut worms, wire worms, etc., which are very injurious to our crops. The life habits of these may be studied in their natural conditions, without disturbing them, by using a root cage, as shown in Fig. 25. It consists of a 10″ × 8″ × 6″ frame, constructed of ½-inch boards, a narrow strip *a* being nailed across the top to hold the frame together; in the two ends and bottom, ½ inch from the edges, grooves *b*, *b* are cut, to retain sheet-iron slides; ¼ inch back of these are grooves *c*, *c*, to hold panes of glass; *d*, *d*, are two grooves for pieces of sheet iron, which are placed so as to leave about 1 inch space between them and the glass panes. This space is filled with soil, in which seeds are planted or small plants are set. Afterwards the larvæ, or eggs, are placed into this space, and their development and movements constantly watched through the glass covers, by removing the outer slides *b b*; the sheet-iron partitions *d*, *d* should be perforated with a number of very fine holes, through which the soil *e e* absorbs moisture from the soil and bits of moss *f* placed between *d d*. The top of *b b* should be bent as shown at *g*; this prevents the light from entering at the top, and keeps the space between *b* and *c* dark.

A collection should be made of the larvæ, pupæ, and eggs of insects in their different stages for future study. Most of this biological material may be kept in alcohol, though many immature states of insects may be preserved by a dry process.

Alcohol has been found to be about the best preservative fluid for soft-bodied specimens, and may be used either full strength or diluted with water. Larvæ should first be put in dilute alcohol, as pure alcohol shrivels them up. A good plan is to place the specimens in alcohol of different strengths successively, using at first a 50-per cent. solution. The specimens should not be left in this for more than five or six hours; they should then be transferred to a 75-per cent. solution for about a day or two, and finally placed in the pure alcohol for permanent preservation. There are certain colorless, or white, grubs and maggots which are apt to turn black when preserved in alcohol; this discoloration can be prevented by dipping them in boiling water, for a few seconds, before putting them into the alcohol.

Glycerin, either pure or mixed with water or alcohol, is often used to preserve the larvæ of delicate insects; it is excellent for preserving the colors, though the internal parts are apt to decay and render the specimens unfit for study.

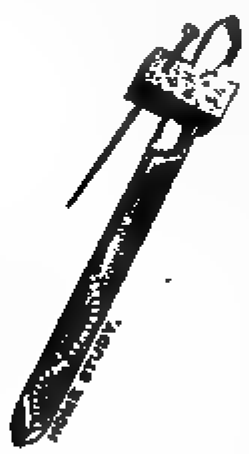
Another good preservative fluid consists of 2 parts of common salt, 2 parts of alum and 1 part of corrosive sublimate, dissolved in ninety-five parts of boiling water; to this after cooling is added 1 part of carbolic acid.

The larvæ to be preserved are placed with the preservative fluid in a small glass vial, Fig. 26 (*a*), closed with a rubber stopper. If the vial is *filled* with the liquid—the air being thus expelled—the contents will be intact and safe for years. The beginner will experience considerable difficulty in putting a stopper in a filled bottle, the liquid always forcing the stopper out again. If, however, a pin is held against the side of the stopper while putting it in, the liquid displaced

FIG. 25.

by the stopper will escape, and when the pin is removed the stopper will be found secure.

For the preserving of very minute larvæ, eggs, etc., a good method is to place the specimen in a thin glass tube, having one end sealed by melting over a spirit lamp. The tube, which should be about 2¼ inches long, is filled three-quarters full with preservative fluid, and is then closed by heating it at the proper length and pulling it out with the other end of the tube until it is drawn to a point. After slightly cooling it, the point may be rounded by again holding it over the flame. During the whole operation, the tube should be held obliquely in the hand, so that the fluid will not wet the heated end, for it is difficult to melt the tube if it is too full, as the quickly expanding steam breaks through the softened mass of glass. The tube may be mounted by boring a hole of the same diameter through a piece of cork. By putting an insect pin through one end of the cork, Fig. 26 (*b*), it may be pinned in the cabinet.



(a) *(b)*

FIG. 26.

Larvæ preserved in alcohol are excellent for anatomical and general study, though often the specimens lose their natural color, making them unsuitable for economic displays. The dry process of preserving larvæ by blowing or inflating, though somewhat difficult and disagreeable to perform, will preserve the form and color. The larvæ is first killed in the cyanide bottle or with chloroform; the viscera are then removed, by placing the specimen on a piece of blotting paper and causing the alimentary canal to protrude ⅛ or ¼ inch by rolling a pencil over the larva from the head to the other extremity, and severing the protruding tip with a sharp knife. Great care must be taken not to press the pencil too forcibly against the larva, nor to continue the operation too long, as this will bruise the skin, and when dry the specimen will show discolored spots and be more or less distorted. The larva should be moved about on the blotting paper during the operation so as not to become soiled. When the contents have been pressed out, insert a straw or glass tube drawn to a point at the outer end, and inflate the skin. If a straw is used, the skin can be fastened to it by thrusting a fine insect pin through it and the straw near the posterior end of the specimen. In using a glass tube, first insert it, then remove it carefully, so as to leave the opening expanded, heat the point of the tube in the flame of a lamp, and insert it in the opening again; this will cause the edges of the opening to adhere firmly to the tube. If the glass tube be cut in two, and a section of rubber tubing inserted between the two pieces, it will make the inflating much more convenient. To get a uniform pressure of air a good method is to attach to the glass tube a small rubber bag previously inflated. Inflate the skin and hold it near the chimney of a lighted lamp to dry. The larva should be turned from side to side, to keep it in proper shape and to dry it uniformly until all the moisture has been thoroughly expelled, great care being taken not to heat the skin too much, or the natural colors will be destroyed.

A very convenient apparatus for drying larvæ skins is shown in Fig. 27 (*a*). On a base *a* are fastened two wire supports *b*, supporting a sheet-iron tray *c*, in which is

(a)

FIG. 27.

placed some fine sand *d* to distribute and equalize the heat. A wide-mouthed glass bottle, answering the purposes of an oven, is placed in the sand bath. The pointed glass tube with the larva skin fastened to it is placed in the oven, and held by a cork with a nick cut in it, and inserted in the opening

of the bottle. A spirit lamp, burning alcohol or methylated spirit, furnishes the heat.

In mounting inflated larvæ, remove the skin, when dry, from the glass tube, and insert in the opening a piece of cotton-covered or silk-covered copper wire, bent around a small piece of square cork, through which an insect pin has been pushed, as shown in Fig. 27 (*b*). The larva is fastened to the wire by putting a drop of glue on the end of the wire before inserting it. With a little experience the most delicate larvæ, and also the very hairy forms of caterpillars, can be successfully preserved.

CURRENT TOPICS.

Mrs. Frederic Honey.

THE SIBERIAN RAILWAY.

THERE is a famous French story teller who, in his writings, combines fact and fiction—science and fantasy—with such deftness that at first sight the reader does not always distinguish the one from the other. A quarter of a century has elapsed since this amusing author, Jules Verne, wrote the book by which he is best known in this country, "Round the World in Eighty Days." It was said at the time to be "highly improbable," or "just possible," that the close connections necessary for the accomplishment of the journey which he described might be made. Twelve or fifteen years later, a newspaper correspondent proved that the feat might be performed—and by a woman—with some days to spare. Now the time is approaching when Jules Verne's eighty days may be halved, and when man may "put a girdle round the earth" in forty days (if not in the forty minutes in which Puck proposed to make his circuit), or even in less time. In making such a journey, the traveler will be carried for a considerable portion of his route over the Siberian Railway, which is now in process of construction. It is a stupendous undertaking, and can be compared only with the great American and Canadian transcontinental lines, although in length, and in difficulty of construction, it exceeds any of these roads.

It is a well known fact that the Russian empire includes more territory than any other excepting only that of Great Britain. But, while the British empire is scattered in all parts of the world, Russia is as compact as the United States. This compactness of form of any kingdom or government has its great advantages; but communication between distant parts of a vast interior is rendered slow and difficult when the ocean cannot be used as a highway of approach, and during a portion of the year the whole of Russia's coast line is ice-bound, and her largest river in Europe, the Volga, flows into an enclosed sea; so that, for purposes of commerce and (in many sections) of exploration, man must trust to other means than the water routes so liberally provided by nature in other countries.

It is said that this Siberian Railway, which now attracts the attention of all civilized nations, was first conceived of in 1854, during the Crimean War, when Russia feared an attack on her Pacific Coast, and realized the need of establishing an easy means of communication with her eastern port of Vladivostok. For many years it was only a dream—a remote possibility—except in the minds of foreign speculators, and, later, of a few employees of the Russian government, who were persistently planning, exploring, and surveying—contented to make haste slowly, but certain that the resistless force of the Great White Czar would eventually accomplish any task which he had decreed should be done. In 1891 the work was begun. The first sod was cut with some ceremony by the heir to the throne, who is now the Czar, and a few lines in the newspapers chronicled the fact. Most readers passed them by, as relating to an event in a remote part of the world with which they had no concern. Only statesmen and far-seeing political economists realized the possibilities involved in this enterprise of their powerful neighbor. Work was begun simultaneously at different points; and under great difficulties it has been pushed steadily forward until the present time, when a large portion of the road is open for travel.

In August of the current year a round trip was arranged for those who wished to visit this heretofore inaccessible region. The

routes from London and Paris to Moscow were familiar to travelers. Thence, they started eastward, and connected with the new railway at Tcheliabinsk, on the western frontier of Siberia, onwards into the heart of Asia to the present terminus of that section at Krasnoyarsk, and back via Moscow to London or Paris again, after an absence of only twenty-six days, and at a total expense for all necessaries of travel, of less than four hundred dollars. A cheap excursion to Siberia! Verily no part of the world is hereafter to be a sealed book.

The popular conception of Siberia has been of a dreary, desolate waste, often covered with snow, serving as a wide prison for convicts who are banished by the Russian government in punishment for offences great or small, and the scene of much cruelty and suffering. The light which has been turned on the picture since the plans for the new railway stimulated travel, shows a different state of things. The territory is so vast that no one district can be taken as representing the whole; and descriptions vary according to the route selected by the traveler, who yet often speaks in general terms of the country as a whole. Convicts there are, in large numbers, and they suffer, as most prisoners do, when undergoing punishment, whether just or unjust; but the horrors of their lot have either been much exaggerated in the past or much modified in the present. Many of them, when their term of punishment expires, receive grants of land from the government, and become settlers, thus contributing to the gradual increase of the scanty population of Siberia, which averages only one person to the square mile. For purposes of comparison, it may be remembered that the population of the whole of the Russian empire is thirteen, and that of our own country is eighteen, to the square mile. The ground is rich in mineral products; gold, silver, iron, and coal mines are all successfully worked. In the fertile regions the soil is well adapted to agriculture, and may yet rival the wheat fields of our western plains, when easy means of transportation bring them into communication with the markets of the world. Many thousands of square miles of forest lands await the immigrant, to whom every inducement is offered by the Russian government.

Siberia includes nearly half a continent, and it is needless to say that its climate varies. Part of it is within the Arctic circle, and there, and for many miles southward, may be found the snow-clad wastes of the Siberia of our imagination. The southern parts have a climate not unlike that of Minnesota, Dakota, or Montana, with extremes of heat and cold, but temperate during a portion of the year.

The story is told of a former Czar of Russia that, when he was consulted as to the route of a railway about to be constructed between St. Petersburg and Moscow, he drew a line on the map with a straightedge from one city to the other, and said, "Let this be your road." The plan in Siberia has been of this character, skirting the Chinese boundary through much of the route; but nature has offered more obstacles there than in the former case. The work was divided into five sections; of these the one to the east and the two to the west have been completed; a fourth is in process of construction; the fifth is untouched. This includes Lake Baikal, a great sheet of water, 50 miles in width by 450 in length, around whose southern shores are mountains which offer the most serious engineering difficulties of the whole route. It is estimated that at least four years will be required for the construction of this portion of the road.

Within the limits of Siberia the length of this great railway will be nearly 5,000 miles. It is being built substantially; the sleepers, though all sawed by hand, are thicker than those commonly used in this country; and, although modern machinery for excavation and for pile-driving has been lacking, yet the work has been well and thoroughly done. Many rivers have been crossed, and the bridges over these are not all built, even where the line is, in other respects, finished. Passengers are ferried over them in summer, and in winter trains cross on the ice. Stations are placed at intervals of about 30 miles. The railway is expected to be complete in every particular by the year 1905, when not less than $275,000,000 will have been expended during the 14 years occupied in its construction. Convicts have been employed to some extent, and their rewards for good work included shortening of sentences and additional grants of land; but they were not acceptable as fellow workers with free laborers, and the practice has been discontinued where other labor can be obtained. In the year 1895 no less than 62,000 men were engaged at one time on the railway itself—apart from all those who were employed at distant points in preparing material to be sent for use by rail, road, sea, and river. The rate of construction increases as the track grows in length, and affords more

rapid and convenient means for transporting the necessary plant and material.

Laid out as nearly as possible in a straight line, the road is not diverted from its course for the benefit of large towns which lie near. There are several of these in this distant region, of which a traveler states that he found "settled communities with municipal governments, enjoying every advantage and many of the luxuries of civilized life." To these towns branch lines will be constructed. The object of the Russian government is to secure the shortest possible route for the transportation of troops and of military supplies; for, although, incidentally, commerce will benefit by this new road, which will open fresh and exclusive markets for Russian produce, yet it is built primarily for military purposes. We are apt to judge of such undertakings from the stockholder's point of view, and to ask: "Will this road pay?" Certainly not—in dividends—for many long years; neither freight nor passenger traffic can pay with so scanty a population; but this is not the object with which it has been built. Cut off from the ocean on all sides, Russia needs and will have an outlet. This demand is one of the signs of increasing vigor of national life; and her power, already predominant in Asia, will be still more strongly manifested in intercourse with other nations when her central government is thus closely connected with the Pacific, the scene of so much of the world's activity at present.

In the light of recent events in China this road becomes of special importance. The action of the Russian government in that quarter has been well timed, as viewed in connection with the rapid improvement in the means of communication with eastern Asia. Russia has now practical control of Manchuria, the northeastern province of China; she has secured a "lease" of Port Arthur, an ice-free port on the Yellow Sea, which will naturally be made the terminus of the road, in place of Vladivostok, which is frozen for a portion of the year. Within a measurable space of time, St. Petersburg and the Pacific will be only twelve days apart, via the Siberian Railway. Europe will, ere long, depend on it for the transportation of mails to the Far East; and thence will come, by the same route, valuable merchandise of light weight, such as silks and choice teas. But the link of steel, which will thus bind the east to the west, suggests possibilities of deeper significance than any that are connected with commercial intercourse of such a character. No more pregnant move has been made on the world's chess board than this new enterprise. None can predict its results. They will form interesting material for the historian of the twentieth century.

THE SPANISH-AMERICAN WAR.

July 21st, 1898. General Wood made military governor of Santiago. General Miles left Guantanamo for Porto Rico.

July 22d. Spanish cruiser Jorge Juan destroyed by American gunboats, and the port of Nipe, P. R., bombarded and taken.

July 25th. Harbor of Guanico, P. R., surrendered, and troops landed.

July 26th. M. Cambon, the French ambassador, requested proposals of peace on behalf of Spain.

July 29th. Ponce, P. R., surrendered to gunboat Dixie.

July 30th. General Merritt arrived off Manila.

July 31st. Battle at Malate, near Manila. American loss (Merritt's report), 9 killed, 47 wounded; Spanish loss (estimated), 500 killed and wounded. Aguinaldo's troops reported to maintain a defiant attitude towards Americans.

August 1st. Total sick at Santiago, 4,239 (the maximum number reported during the period of occupation).

August 3d. Bombardment of Manila by insurgents.

August 4th. Monitor Monterey and transports arrived at Manila. Lighthouse station at Cape San Quan, P. R., taken.

August 5th. Guyama, P. R., taken and occupied by General Miles.

August 6th. Troops sail from Santiago for home ports.

August 9th. Capture of Coamo, P. R. American loss, 7 wounded; Spanish loss, 12 killed, 180 prisoners. Spanish attack on Malate repulsed.

August 11th. Spain accepts terms of peace, which are as follows:

1. Renunciation of Spanish rights in Cuba.

2. The cession to the United States of Porto Rico and other Spanish islands, including one in the Ladrone archipelago.

3. The retention of Manila by the United States until all details with regard to the Philippines are decided by treaty.

4. Immediate evacuation of Cuba and Porto Rico by Spain.

5. The United States and Spain to appoint commissioners to arrange finally the terms of peace.

6. The suspension of hostilities.

August 12th. Peace protocol signed, and an armistice declared by President McKinley. Orders given that blockades be raised, and all military operations be suspended.

August 13th. Bombardment and surrender of Manila before news of the armistice was received. Land and naval forces were engaged. Squadron uninjured. American loss (Merritt's report), 8 killed, about 50 wounded; 7,000 Spanish prisoners taken.

The Spanish-American war is thus terminated, having extended over a period of 113 days, from April 21st to August 12th.

THE KITCHEN.

Mrs. Henry Esmond.

HOW TO TAKE PROPER CARE OF IT, AND OF THE UTENSILS USED IN COOKING.

THE kitchen should be kept just as clean as any other part of a house. The mere fact that one's callers do not see it is no reason why it should not be as neat, in its way, as the drawing room; and it should not be allowed to get "upside down" during the preparing of a meal.

In order to prevent untidiness, clear up as you go along; if you make a cake, wash the bowls, spoons, etc. while the cake is baking. By washing them right away, in cold water, the flour and egg can be removed very easily, whereas if they are left to get *dry*, it is exceedingly difficult to get them clean. It is a very good plan to have the table which is used for mixing cakes, pies, bread, etc. covered with white oilcloth; this is very easy to wash, and, if nothing hot is ever placed upon it, will keep fresh for a year or more. Always scrape the pastry board as clean as you can before washing it. Wooden spoons are the most desirable for mixing with, as they are lighter and much easier to hold than tin or iron ones, when there is much beating to be done. Next, everything should be kept neat about the stove. Keep an old whisk with which to brush off the top of the stove. If anything that is cooking boils over, do not leave it to burn, but brush it off or rub it off with a newspaper. Above all, do not put refuse, such, for instance, as potato parings, and the trimmings from meat, into the coal pail; they not only make a bad smell when burning, but attract flies and look very unsightly. Keep a large cullender for refuse, so that any water that happens to be with it will drain off and leave the remainder dry enough to burn later on. After broiling, the stove is apt to have a great deal of grease on it which has sputtered from the meat; clean this off with a piece of paper; rub the stove top quickly with this, and you will find that it not only takes off the grease but makes the stove clean and bright.

If the floor of your kitchen is not hard wood, have it covered with linoleum; if you cannot afford this, have it painted—not a dark brown, but some light color, such as yellow or orange. Dark colors do not keep clean any longer than light ones; they only hide the dirt. The reason for covering a soft-wood floor is that grease, milk, or anything of an oily nature that happens to be spilled on it, soaks in and leaves a mark which can never be entirely removed.

If you cannot afford screens in the kitchen windows, get mosquito netting and cover the whole of the window frames on the outside; the windows can then be opened from the top as well as from the bottom, a thing very necessary when it is desired to get the smoke and smell of cooking from the room.

Rugs of any kind are entirely out of place in a kitchen, as they get kicked up and are apt to trip one when carrying hot dishes, pots, etc.

One cannot be too careful about the cleanliness of the sink. Unless it is washed carefully every day it will get stopped up and attract water bugs. No refuse, such as the scrapings from the dishes and pots, should be thrown into the sink, neither should the coffee grounds be emptied there. The coffee grounds and small pieces of refuse will get down the pipe and clog it up. Throw all such things into the before mentioned

cullender. Do not throw greasy water—the water that corned beef has been cooked in for instance—down the sink. The grease will harden and remain in the pipe, and with particles of refuse will stop it up. Either throw such water into an outside drain or let it get cold, when the fat will form a cake on the top and can be easily removed. After the dishes have been washed, gather up all particles in the sink with a brush made for that purpose or an old whisk ; then let the hot water run, and with soap and brush thoroughly scrub and clean the sink. In case the pipe gets stopped, a handful of washing soda placed over the hole, and boiling water poured over this, will usually remedy it. When the sink is clean, wipe it dry with a cloth; and always wipe the woodwork too. This may seem to some unnecessary to do every day, but if you want a clean, sweet smelling sink, free from water bugs and ants, you cannot be too careful. To get rid of water bugs and ants, sprinkle powdered borax all around the sink and around the surbase in the room.

The washing of dishes is an accomplishment which very few are proud of and which but few maids do well. In removing the dishes from the table, take one at a time and do not pile the saucers and butter plates onto the dinner plates. Scrape each plate carefully, and if necessary rinse off with cold water. Put all the plates in one pile, the saucers and butter plates in others, and all the forks and spoons by themselves. Have the water boiling hot. Do not leave the soap in the water, but keep it in a cup, and, when ready to wash the dishes, shake it through the water until the latter becomes soapy enough ; then drain all the water out of the cup and set it aside.

If you do your own work, the most desirable thing for washing dishes is a dish mop—you can use very hot water and need get only the tips of the fingers wet. There are few maids who will use one; they apparently prefer the old dish cloth and the red, rough hands that accompany its use.

First wash the glasses. Putting them in sideways prevents their breaking. Have a clean, dry towel that is not linty, take the glasses from the water one at a time and dry immediately. Set them on the shelf, handling them through the towel and not with the bare hands, as the moisture from the hands will mark them. Do not rinse them off after taking them from the hot, soapy water; if they are dried as soon as they are taken from the water they will be bright and clear. Next, wash the cups and saucers, then the silver, drying as soon as taken from the water. After this, wash the vegetable dishes, then the plates, platters, etc. If there are a great many dishes and the water gets cold, wash the last of the dishes off once, then get fresh water and wash them again. Always use fresh water for the cooking utensils; they should be scraped and washed just as carefully as the others. If there are any stains on the pots or lids, clean them with sapolio.

Wash the knives quickly, never allowing them to get under water, as the handles will become loosened, and, if ivory or bone, a dark color. Clean them first with powdered bath brick, then sapolio. Have a small board to clean knives on ; rub them with a large flat cork ; wipe them off with a wet cloth and dry thoroughly with a dry cloth. Egg stains on spoons can be removed with a little dry salt, rubbed on with a cloth.

Wash the dish towels in clean, warm water after every meal, and put them out doors to dry ; it only takes a few minutes to do this, and you have the satisfaction of knowing that your dishes are wiped with clean towels. How can you expect bright, clean dishes, if they are dried with dirty towels?

Keep rice, tea, coffee, raisins, etc. in glass jars ; then they are safe from mice. Sugar should be kept in tin or wooden boxes made for the purpose. When using sugar, take the box out to the table where you are working ; do not dip into the box for a cupful, and run the risk of spilling it on the shelf to attract ants.

Food that is left over should never be set away in the dishes it was served in. Nothing shows a lazy housekeeper so much as this ; it is not only a very dirty habit, but the dishes may get broken. Instead, put what you wish to save into heavy white dishes kept solely for that purpose.

Great care should be taken with the refrigerator. Nothing with a strong odor, such as fish, onions, melons, etc. should be put into it, as butter and milk absorb odors of any kind very quickly and the refrigerator itself becomes saturated with odors. It should be washed with hot, soapy water at least twice a week, and the shelves put out in the sun to dry.

In buying utensils, do not get tin ; it may seem cheap in the beginning, but it is in reality expensive, as it soon becomes black, and food cooked in it burns very easily. Granite or porcelain ware is best, or iron will

do if you cannot afford the others. Porcelain and granite ware are not as expensive as they used to be, and if they receive no hard knocks, and water is not allowed to boil off in them while on the stove, they will last a long time. In fact, if carefully used, it is surprising how long kitchen utensils and china will last.

It would be a waste of time and space to attempt here to give a list of the cooking utensils needed in a kitchen, for it all depends upon the "length of one's purse." Every one knows what the first necessary articles are, and as you go along you will soon find what others you need. There is no sense in buying utensils for making fancy dishes if you only cook the plainest food in the simplest way. Asbestos mats are very little used, probably because they are not well known; they are very useful, however, to put under anything that has to cook long and slowly. They prevent burning and sticking to the bottom of the kettle, and are very cheap, costing only 5 cents each.

MY HOBBY.

SOME years ago, the London "Punch" contained a cartoon drawn by that famous artist, Sir John Tenniel, representing a prominent politician locked up in the cell of a lunatic asylum, astride of a wooden rocking horse named "Hobby." The leader of his party, who had called, contemplated him sadly as he said, "What is the difference, Sir Charles, between a hobby-horse and a real horse?" The rider answered "You can get off the real horse, my lord."

Well, it may be that the inference is true—that many a man finds it difficult to dismount from his favorite hobby horse—but does not that prove that he has a pretty firm seat upon it? And is it not better to have a firm seat upon a hobby-horse than to have no horse at all, upon which to elevate oneself a trifle above those who merely stand around?

The man who has neither a real horse nor a hobby-horse—in other words, the man who, belonging to the great majority, works, for a modest salary, that some one else may ride, without even a hobby to sport upon at will—is surely away behind his brother toiler who revels independently during spare hours astride his favorite hobby.

"What I like best about a man," said Field, "is his fads." A man is never so entertaining as when, forgetful of himself and of all who listen, he talks about his hobby. It is then he is seen and heard at his best. It matters not what the hobby may be; whether geology to carry his mind back to live, for the time being, millions of years ago; or astronomy to fill him with wonder at the awful immensity of space and the mathematical exactness of the laws that govern the movements of the heavenly bodies; or zoology, accompanied by an attempt to discover the origin of man; or entomology, to make him wise about the lives and habits of insects; or microscopy to reveal to him the ways of the "invisible" wonders of creation; or photography, or music, or painting—the subject makes no difference; if it is the man's hobby, he *knows* it, independently, from his own observation, and is an authority upon it—for which reason alone, what he says about it is of interest and value to others.

A hobby engenders independence of thought and action, and with these come greater self-respect. An employee, whatever his business may be, is responsible to his employer, and his work must please that employer, otherwise his place will soon be filled by some one else. But while a man is working at his hobby he is his *own* employer; he has no one to please but himself, can "take his own time about it," is free to make as many experiments as he chooses, and is independent of all the world.

Some men who make more of their hobbies than others, and progress further, are called "cranks." It has been said that a crank is one whose hobby is not the same as your own. Perhaps it would be better to say "a crank is one who has learned more from his hobby than you have." Of course, there are cranks *and* cranks, but thank heaven for them anyway—it is they who keep the world moving. However, it is not wise to start out with the idea of *becoming* a crank; a hobby should be kept under control, the man ever remaining master, and never allowing his hobby to change places with himself; otherwise, the answer which Sir Charles gave to the leader of his party will have for him a very serious meaning.

THE illustration on this page represents a compressed-air engine, specially designed for use in coal mines where the height and width is limited. The particular work for which it was designed is for what is known as flat workings with a head clearance of but 36 inches above the top of rail. Before the use of the motor, the bottom of the working had to be taken out in sufficient quantity to give a depth that would permit of the use of mules. To avoid that expense was the purpose of this design, the use of which has not only been a saving in the cost of mining mentioned, but in lessening the direct cost of hauling the cars as compared with mule haulage. The work of the motor is not confined to any particular portion of the workings. It is, in reality, an inside shifting motor, or engine, running in and out of the workings, delivering empty cars, and taking the loaded to the main line, where they are hauled in trains to the point of delivery.

In the construction of the motor, on account of the limitations of height, Mannesmann tubes have been used for the main storage of compressed air. As shown in the cut, these are laid in line, but in addition to those seen are a number of others between the frames, wherever it was possible to place them. The tubes are connected with copper pipe and extra heavy brass fittings to a pipe that has two connections to the pressure reducer, which reduces from the storage pressure of 700 pounds, to 125 pounds per square inch, the working pressure in the auxiliary storage, from which the air is led direct to the throttle and steam chest. The main storage system is made up of two series, each with suitable shut-off valves, with falling connections and check-valves. With this arrangement, should any connection fail in one series, it can be cut out and the other used, and thus prevent the motor from becoming "dead." The arrangement of storage tubes between the frames, leaving no room for the use of links and eccentrics for valve motion, the Walschaert gear has been used, as shown, and with advantage in the motor's operation. The limited conditions in the design and working of the motor also cause a limit in the dimensions of the operator's place, which is at the cylinder end of the motor, in a box between the frames, reaching to the lowest point above the rails consistent with safety should the motor become derailed. To further guard against injury from this cause, a safety guard is placed below the bumper beams that will sit upon the rails should the motor become derailed. As the position of the operator is fixed when the motor is in service, the throttle and reverse lever are placed one at each hand, and all valves and cocks that operate the engine are within his reach. The designers and builders of this engine are The Dickson Manufacturing Company, Scranton, Pa.

CATALOGUE REVIEWS.

"A Book of Tools," by Chas. A. Strelinger & Co., of Detroit, Mich., is now in its third edition of 50,000 copies. On the title page, the compilers have called it "A catalogue of tools, supplies, machinery, and similar goods used by machinists, engineers, blacksmiths, model makers, founders, molders, draftsmen, inventors, and amateurs, and in manufactories, mills, mines, etc., etc." As a matter of fact, "A Book of Tools" is

even more than all this. In the first place, it is far more than an ordinary trade catalogue, for it contains a vast amount of valuable information on the use of tools and workshop appliances. It is in places as interesting as a novel, among the best chapters being those on labor-saving tools, lubricating oils, glues, emery grinders, the vernier and its use, drill chucks, second-hand machinery, and economy of the machine shop. It contains 523 pages over 2000 illustrations, and is written in such an "upright, downright" manner as to convince any business man of the truth of the statements made and the value of the advice given. Regarding its very convenient size ($7\frac{1}{2}'' \times 5\frac{1}{2}'' \times 1\frac{3}{8}''$ thick), the following quotation from the preface will serve: "For many years, catalogues have been growing larger and larger, until things were getting to such a pass that it became a grave question as to whether manufacturers would not have to put up special library buildings for trade catalogues. In our judgment, the book that is to be constantly used should be small and compact. A small engraving well done is, in the majority of cases, just as useful for the purpose intended as a large one, and there is no more need of showing a full-size cut of a blacksmith's sledge than there is of showing a full-size cut of a hundred-foot tape line. On account of its small size, this book can be kept in the desk and constantly referred to (this is what we like), or can be carried in the pocket, an especially useful feature when one goes out to estimate on work for which various tools and supplies may be required."

Chas. A. Strelinger & Co. are themselves large manufacturers, using, in the various departments of their works, a majority of the tools in which they are dealers. This places them in an excellent position to discover, by trial, the actual quality and usefulness of a tool before they recommend it to a customer. The price of extra copies of "A Book of Tools," paper covered, is 25 cents; handsomely bound in cloth, 75 cents.

Chas. A. Strelinger & Co.'s "Woodworker's Tools" is similar in aim to "A Book of Tools," and is about the same size and printed in a similar style; it is, however, especially devoted to tools, supplies, machinery, and similar goods used by carpenters, builders, cabinetmakers, patternmakers, millwrights, carvers, ship carpenters, inventors, draftsmen, and all "wood butchers" not included in the foregoing classification. The price of extra copies, paper covered, is 25 cents; printed on heavier paper and handsomely bound in cloth, $1.00.

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THE DICKSON MANUFACTURING CO., of Scranton, Pa., have recently published a new catalogue of the locomotives built at the Dickson Locomotive Works. The small size of this book is an indication that the large and unwieldly catalogues, already referred to in these "notes" are soon to be a thing of the past. On glancing through it, one's first impression is that every page "means business"; in fact, we are informed that none but engines that have actually been built by the company are illustrated or described therein. Immediately following the preface there is a very instructive chapter entitled "Hauling Capacity and Dimensions," containing formulas and tables invaluable to a prospective purchaser of hauling machinery of any kind. The size of the book is $6'' \times 9''$; it contains 72 pages and is handsomely bound in cloth. There are 29 full-page half tones, excellently done, of the various types of engines built by the concern, tabulated statistics accompanying each illustration, with concise information of the following nature: Weight on driving wheels, total weight of engine in working order, driving-wheel base, total wheel base of engine, total wheel base of engine and tender, diameter of cylinders, stroke of piston, diameter of driving wheels, diameter of engine-truck wheels, working boiler pressure, diameter of boiler at front end, length of firebox, width of firebox, number of tubes, length of tubes, diameter of tubes, tube heating surface, firebox heating surface, total heating surface, grate area, tank capacity, hauling capacity, etc.

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SEYMOUR S. BLASDELL, of Scarsdale, Westchester Co., N. Y., publishes a 32-page pocket catalogue of electric supplies and novelties manufactured by him. Therein are described a special line of batteries for use in place of dynamos in electric lighting for private houses; also a rheostat specially adapted to the wants of experimentalists, an improved battery powder, miniature incandescent lamps, electric-bell outfits, "baby" motors, ventilating fans, phonograph-battery outfits, induction coils, etc.

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JAMES L. ROBERTSON & SONS, of New York, issue an illustrated catalogue of their well known Robertson-Thompson indicators, in which the instrument is fully described with the help of very capital drawings of the

various details of the mechanism. The catalogue contains also illustrations and descriptions of the "Victor" aluminum reducing wheel for use with the above indicator, various planimeters, Robertson's live-steam separator, exhaust-oil extractor, shaking and dumping grate bars, exhaust-pipe head, waste-oil filter, and other steam-users' requisites.

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E. C. Stearns & Co., of Syracuse, N. Y., have a beautifully gotten up catalogue of the hardware they manufacture. Size of book 6″×9″, 90 pages. The illustrations throughout are of a very high quality and represent a large variety of goods—doorhangers, sash balances, window screens, wire cloth, patent screen fastenings, spring hinges, door checks, lawn-mowers, jack-screws, hammock hooks, casters, clothes reels, plumber's goods, carpenter's tools, saw vises, augers, blacksmith's tongs, bicycle stands, hitching posts, etc.

BOOK REVIEWS.

The Science of Nutrition. By Edward Atkinson, LL. D., Ph. D. Cloth, size 8½″ × 6½″, 246 pages. Illustrated. Published by Damrell and Upham, Boston. Price, $1.00.

Here is a book that should be in every household. It is not merely a collection of recipes—though it contains some 300 excellent ones—but a scientific work. Among the most interesting chapters are those on Composition of Food Materials, Food Power, Economy in Food Materials, and Expensive versus Economical Foods. These chapters and other parts of the book contain many very instructive and valuable tables on Percentages of Nutrients in Food Materials, Digestibility of Foods, Dietaries, Comparative Expensiveness of Foods, Prices of Foods, etc. Mr. Atkinson is the inventor of the famous Aladdin oven, the uses of which he describes in detail. The book is in the main a discussion of the values of food materials, and the best ways to cook them so that they shall retain their most valuable nutrients without loss of their most subtle flavors.

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Gas, Gasoline, and Oil Engines. By Gardner D. Hiscox, M. E. Second edition, revised, and enlarged. Published by Norman W. Henley & Co., New York. Price, $2.50.

This work, like the first edition of the same, contains a large amount of descriptive matter relating, in a great measure, to engines of American manufacture. A considerable amount of interesting material has been added to the second edition, which contains about 80 new illustrations. The descriptive matter, for no apparent reason, omits several prominent engines, notably the Westinghouse, and it also entirely ignores the latest motor in the field, i. e., the Diesel motor. It is also to be regretted that errors, such as may be excused in the first edition of a work of this character, are repeated in the second edition. There is no reason, however, why this work should not be of great service to the gas engineer, as much valuable information is contained therein.

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Home Health Club, Vol. I, Preparatory Course. By David H. Reeder, M. D., Ph. D. Size 7″ × 5″, 174 pages. Published by The Inter Ocean Publishing Co., Chicago, Ill. The ownership of this book carries with it a life membership in the Home Health Club, the object of which is to spread among all mankind a knowledge of the laws of health. Dr. Reeder advocates a return to simpler modes of living, less artificiality, more outdoor exercise, and simple foods, properly cooked. He lays great stress on a right manner of life, moderation in everything—particularly in eating and drinking—and upon the paramount importance of drinking plenty of pure water, preferably distilled. There are excellent chapters on bread and foods, the latter containing tables of the nutritive values of different foods and their digestibility.

Note.—In Home Study Magazine, June, 1896, Answers to Inquiries No. 196 (*b*), M. A. G. asked for information that we were unable to give him regarding the pneumatic mattresses used on shipboard. We are now able to state that these are manufactured by The Pneumatic Mattress and Cushion Company, Reading, Pa. This firm will no doubt be willing to give the information desired.

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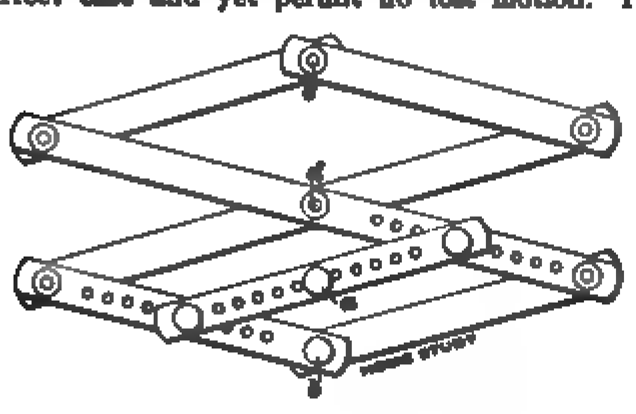
(389) Please explain how a pantograph is made. I want to make one to enlarge pictures for painting.

C. G. P., Seneca Falls, N. Y.

Ans.—For enlarging pictures the pantograph should be made as light as is consistent with strength and rigidity. There must be no loose joints. To insure this, where wood is used in the construction, the joints should be made of metal. So neatly fitted should the joints be, that they should operate with perfect ease and yet permit no lost motion. The



form of the pantograph is shown in the sketch. The point *b* is fastened so as to permit free movement to all the other parts. When the point *a* traces the picture, then a pencil point *a*, *d*, or *c* will trace an enlarged reproduction of it. The closer *a* is to *b* as compared to *c* or *d*, the greater the scale; in other words, ratio of distance *cb* to distance *ab*, or $\frac{cb}{ab}$ = scale of enlargement. The holes shown are for the purpose of changing this ratio when desired.

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(390) By what process are bicycle spokes swaged? Is it done hot or cold, and what kind of a machine is employed? Are there many of the machines in use, and are they on the market?

M. B., Plymouth, Ohio.

Ans.—We are indebted to the Pope Manufacturing Company, Hartford, Conn., for the following: "The spokes are swaged cold in machines made especially for the purpose, one or two designs of which, however, are now a regular commodity in the market. What is probably the best known type of machine is manufactured by the Excelsior Needle Company, of Torrington, Conn. The principle upon which the different machines operate is essentially the same, there being only minor differences in the manner of applying the blow or bringing the die blocks to the work. The wire to be swaged is fed by a screw automatically or drawn by hand through a head in which is carried a holder for the die block, which is rotated so as to bring the ends of the die blocks in contact with a number of rolls mounted in a ring, backed up by a heavy casting which encloses the whole mechanism. The speed is regulated to give about 9,000 or 10,000 blows per minute. This means a rotation of the head of about 1,000 revolutions and nine or ten rolls in the ring, higher frequency of impact would be accomplished by increasing the number of impact rolls in the ring above mentioned, against which the die blocks come in contact. One type of machine rotates the ring of rolls past the ends of the stationary die blocks. In this case, the wire to be swaged is given a rapid rotary movement; in the system above described the wire is rotatively stationary. The ratio of feed of the work to movement of the blocks is about $\frac{1}{100}$ of an inch per blow of the dies. It will be seen that the duty of the dies at such speed upon a piece of work being drawn, say from .085 inch to .060 inch is very great, consequently, the dies are made of the very best steel obtainable and very carefully tempered, and are lapped to exact shape for contact with the work, with brass plugs tapered to the proper angle, which is about 15 degrees. The duty upon the dies varies, of course, with the hardness of the wire to be swaged and the rapidity with which the work is drawn through them, the smoothest and best work being done at a moderately fine feed—everything else being equal. In successful swaging, the work comes out perfectly smooth, superior, in fact, to a polished surface. The full reduction of a bicycle spoke is made at one passage through the dies. Greater reductions than these referred to might be accomplished by two or three passages through the machine, with annealing and pickling between the operations. Excessive reduction of diameter in one swaging operation is liable to cause the separation of the fibers and scaling of the stock, which would be avoided by the annealing, which restores the natural arrangement of the molecules of the stock. The operation of swaging, if not carried too far, adds to the tensile strength of the wire if it remains unannealed."

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(391) What is the more common name for the "tungstate of soda" mentioned in Answers to Inquiries, No. 221, in your June number? I cannot find the name in the United States Dispensary.

L. A. W., Wells, Minn.

Ans.—Sodii tungstas ($Na_2W_1O_4 + 2H_2O$), or tungstate of sodium.

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(392) Can you suggest any plan or receipt by which I can polish a locomotive boiler head a brilliant black? I am now using benzine paste, but it is not impervious to moisture, at any rate, water specks its surface and destroys the gloss. Enameline is not sufficiently lustrous, though more lasting than the benzine paste. The boiler is standard; steam pressure, 165 pounds gauge.

H. E. McC., North Platte, Neb.

Ans.—We know of nothing in use at the present time that will answer your requirements. The

Note.—For conditions to be observed by subscribers wishing to have questions answered in this department, see contents page.

following preparations have been suggested, however, and are said to give fairly good results if properly made and applied: (1) Mix 2 parts of black lead, 4 parts of copperas, and 2 parts of bone black with sufficient water to form a paste of about the consistency of cream. The copperas produces a jet-black enamel, causing the black lead to adhere to the iron. (2) Mix 5 parts black lead, 5 parts bone black, and 10 parts of iron sulphate with sufficient water to form a paste. This is said to give a very permanent coating.

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(393) Under what conditions is "anchor ice" formed in the winter time? Is the specific gravity of this ice greater than that of water?

WHALEBACK.

ANS.—The density of water at 32° F. is always greater than that of ice. Anchor ice, or ground ice, is only seemingly an exception. If any particles of anchor ice are broken loose from their hold they will immediately rise to the surface. Anchor ice, then, may be the lower stratum of ice, in a shallow stream that has been entirely frozen, remaining after that above has become melted, or it may be formed in swift-running streams that have rough and rocky bottoms, probably by the cold surface water being carried to the bottom by eddies, thus cooling the rocks until small crystals of ice, which are also carried down, adhere to them.

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(394) (*a*) I have an engine which runs at 280 revolutions per minute. The engine pulley is 18 inches in diameter; the pulley on the main shaft is 40 inches in diameter. If I put a 12-tooth sprocket wheel on the main shaft and drive a 29-tooth wheel on another shaft, on which shaft I place a 44-tooth wheel driving a 13-tooth wheel on a third shaft, what size pulley must I put on this last shaft so as to drive a fan that has a pulley 6 inches in diameter, at a speed of 500 revolutions per minute? (*b*) How many revolutions will the fan make if I drive it from a 27-inch pulley?

L. P. K., Hammond, Ill.

ANS.—(*a*) You have here 5 shafts—reckoning the engine shaft and the fan shaft. Let us call these *A*, *B*, *C*, *D*, and *E*; *A* being the engine shaft, and *E* the fan shaft. *A* makes 280 revolutions per minute, and you wish the 6-inch pulley on *E* to make 500; but you have certain pulleys and sprocket wheels between shaft *A* and shaft *D*. First find the speed at which these pulleys will drive *D*. This speed will be found to be $280 \times \frac{18}{40} \times \frac{12}{29} \times \frac{44}{13} = 176$ revolutions per minute; this is approximate and allows for no slip of the belt. Now, $\frac{500}{176} = 2.83$, and if the diameter of the pulley on *D* is 2.83 times the diameter of the pulley on *E*, or $2.83 \times 6 =$ about 17 inches, the required fan speed will be obtained; thus, the speed of fan shaft *E* will be $280 \times \frac{18}{40} \times \frac{12}{29} \times \frac{44}{13} \times \frac{17}{6} = 500$ revolutions per minute, about. (*b*) With a 27-inch pulley on *D*, instead of a 17 inch, the speed of the fan will be found to be $280 \times \frac{18}{40} \times \frac{12}{29} \times \frac{44}{13} \times \frac{27}{6} = 794$, about. This suggests another way—by simple proportion—of arriving at the desired diameter, thus:

$794 : 27 = 500 : x$; whence $x = 17$ inches, about.

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(395) (*a*) Can you give me a little information regarding the size of ports for a cylinder using compressed air? The case in point is as follows: I have a steam pump which has a 10-inch steam cylinder, a 5-inch water cylinder, and a 12-inch stroke; the piston speed is 100 feet per minute against a head of 150 feet. I wish to substitute, for the steam, compressed air at a pressure of 30 pounds per square inch. The steam and the exhaust ports are now $\frac{3}{8}'' \times 4''$. Kindly give me a rule whereby I can determine the proper size of the ports in this and similar cases. (*b*) Also give me a method for figuring the induction port of an air compressor; the valve is a plain slide valve, worked by an eccentric.

W. V. Holyoke, Mass.

ANS.—(*a*) Ports designed for the use of steam may be used for compressed air without any change except that in the case of high pressures the exhaust port must be so arranged as to provide for the removal of the ice formed by the sudden expansion and cooling of the air. A formula that is generally used for finding the area of steam ports is

$$l\,b = \frac{A\,S}{v}$$

where, l = length of port in inches;
b = breadth of port in inches;
A = area of piston in square inches;
S = speed of piston in feet per second;
v = 100 for long and indirect passages, and 125 for short and direct passages.

The area of the exhaust port may be about $1\frac{1}{2}$ times the area of the steam port. (*b*) The above rule for finding area of steam ports may be used for the area of induction ports for an air compressor; since, however, it is important that there be a free admission for the air, it would be well to increase the value given by this rule by 50 per cent. if the conditions allow.

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(396) I am looking into the merits of gasoline engines for power for a planing mill. What, in your opinion, are the advantages of a two-cylinder engine having an explosion at every revolution?

C. C. G., Attleboro, Mass.

ANS.—A two-cylinder gasoline engine runs more steadily than a single-cylinder engine; hence, the regulation is more perfect and the vibration less. Three-cylinder and four-cylinder engines have similar advantages over the two-cylinder type.

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(397) (*a*) Kindly give me the dimensions for a set of lenses for a camera, size of plate $2'' \times 2\frac{1}{2}''$; also for a $4'' \times 5''$ plate. (*b*) What books on this subject would you recommend to an amateur?

A. B. H., St. Mays, Ill.

ANS.—(*a*) Without entering into a long discussion on the advantages and disadvantages of long and short focus lenses, it would be difficult to definitely answer your question. By the term "dimensions," we assume you refer to the focal length of the lens, as that is the only "dimension" which affects the size of the picture. Lens manufacturers usually make the focal length of the lens about equal to the diagonal measurement of the plate to be covered; thus, a $2'' \times 2\frac{1}{2}''$ plate would require a lens of about $3\frac{1}{4}$ inches focal length, and a $4'' \times 5''$ plate would demand a lens with $6\frac{1}{2}$ inches focus. This rule, however, is not a fixed one, as a wide-angle lens, suitable for interiors and objects at close range, might have a focal length of only $2\frac{1}{2}$ inches for a $4'' \times 5''$ plate, and a telephoto lens, such as is used for photographing distant objects, would require a focal length of about 60 inches to work satisfactorily on the same size plate. According to the purpose for which it is to be used, then, a lens may be of either long or short focus for the same size plate. The diameter of the lens, or size of its opening, will affect its speed, but not the area covered by its illuminating power. (*b*) Textbooks of Science, subject, Photography, by Capt. W. DeW. Abney. Price, $1.25. This book can be purchased from The Technical Supply Co., Scranton, Pa.

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(398) (*a*) How many cells will it require to run a 3-horsepower electric motor? The motor is to be wound for the batteries in such a manner as to get the best result. The cells I shall use give 30 amperes at 2.1 volts, and are good for 300 ampere hours; the batteries are non-polarizing. The motor will have to

do some very stiff work at times, but it will never be run for more than 6 hours at a time. (*b*) What is the ultimate tensile strength of a 1¼" × 1" bar of cast steel as it comes from the foundry?

O. A. T., Syracuse, N. Y.

ANS.—(*a*) In case you wind your motor to take 30 amperes, that would mean a required pressure of 75 volts, and would require 36 cells in series. By putting them 18 in series and 2 in multiple, you would reduce the internal resistance to one-fourth that obtained with all in series, and obtain 60 amperes at 37½ volts. Thus, by arranging the cells in various ways, any pressure, from 75 to 2.1 volts, may be obtained, the current varying at the same time from 30 amperes to quite a large figure. Your best arrangement probably is to put them all in series and wind the motor for 30 amperes at 75 volts. (*b*) The tensile strength of cast steel varies from 50,000 to 100,000 pounds per square inch, depending on the grade of steel. Then a bar 1¼" × 1" would have a tensile strength varying from 62,000 to to 125,000 pounds, the average running about 80,000 pounds for a 1¼" × 1" bar.

* * *

(399) (*a*) Of what material are graphophone coils, or rolls, made? (*b*) How are they polished? (*c*) How many times does the cylinder revolve to 1 revolution of the screw, and how many teeth are there in the cylinder gear, and what is the size and pitch of the screw?

T. T., Akron, O.

ANS.—(*a*) Graphophone record cylinders are made of wax by a process which is a trade secret. (*b*) They are not polished, the knife used to true them up leaving a sufficiently smooth surface. (*c*) The gear on the cylinder spindle has 16 teeth, and that on the screw has 40 teeth, so that the screw revolves once to each 2½ revolutions of the cylinder. The screw is about ⅛ inch in diameter, and has 40 threads to the inch.

* * *

(400) I wish to make an induction coil, using for the secondary 10 pounds of No. 39 bare copper wire, wound with a cotton or silk thread between the turns. (*a*) Which size is best for secondary, No. 36 or No. 39? (*b*) Give dimensions of primary coil for above, also of secondary coil, size and length of core, and size of condenser. (*c*) What should be the space between the primary and the secondary coil? (*d*) What will be the length of spark? (*e*) Will a gravity battery, with plates 1 foot square, be practical, and what number of cells will be required, either in series or in parallel? (*f*) Would the length of the spark be increased by using a 50-volt alternating current in the primary? (*g*) Could a high-frequency coil be used in connection with this induction coil, and what size of same would be best to use, and what results might be expected?

A. N. D., Springfield, Mass.

ANS.—(*a*) The selection of the size of wire to be used depends on the requirement as to the spark. If a short, thick spark is desired, use a thick wire, say, No. 36 B. & S.; if a long, thin one is wanted, use No. 39. (*b*) Use a core of 1¼ inches diameter by 18 inches long. Wind two layers No. 12 B. & S. wire on the core for the primary. The coil should be, say, one-twelfth of the core length shorter than the core. Use a condenser made from a quart fruit jar. (*c*) Great precaution should be taken in insulating the secondary from the primary; also, in insulating the primary from the core, and the different layers from each other. Between the primary and the secondary put a glass or hard-rubber tube, free from flaws. Let it extend at least one-tenth the length of the primary coil beyond it at each end. The thickness required depends on the dimensions of the coil. (*d*) A coil with 10 pounds No. 39 wire should give a 6-inch spark if properly constructed. (*e*) No; the current from gravity batteries is so feeble that an immense number would be required. (*f*) An alternating current would not increase the spark, and is objectionable if the coil is to be used for X-ray work. If batteries are to be used, some good open-circuit battery is desirable, but the storage battery or the direct current from a dynamo is preferable. (*g*) If by "high frequency coil" is meant a Tesla disruptive coil, yes. The ratio of secondary to primary turns for the Tesla coil may be 24 to 1. The results from a Tesla coil, properly connected, are most satisfactory for X-ray work.

* * *

(401) (*a*) What are the carrying capacities of wires in coils from No. 10 to No. 36 B. & S.? (*b*) What are the number of strands to the inch of from No. 14 to No. 36 magnet wire? (*c*) Referring to HOME STUDY MAGAZINE, April, 1898, Answers to Inquiries, No. 117, I do not understand why the admission and exhaust ports should be so large for a 2-horsepower Day type gas engine, the same size being to my knowledge used in a 6-horsepower gas engine of another type. (*d*) Will you kindly publish a sectional drawing of the governor and air valve of the Day gas engine described in HOME STUDY MAGAZINE, February, 1898? (*e*) Would the valve shown in the enclosed figure be the right size and a good design for a 4" × 5" Day gas engine? (*f*) Give the carrying capacity in amperes and the resistance of German silver wire from No. 14 to No. 36.

F. K. B., San Francisco, Cal.

ANS.—(*a*) (*b*) and (*f*) This information may be obtained from the catalogue of The American Electrical Works, Providence, R. I. The catalogue will be sent on request. (*c*) The sizes given in Answers to Inquiries, No. 117, represent average practice. Too small a port will lower the efficiency of the engine. The ports on the 6-horsepower engine, to which you refer, are evidently too small. (*d*) If you will read the description carefully, you will see that the Day engine has no air valve on the engine described. In a later form of the Day engine, a poppet valve is used for the air. The most satisfactory apparatus for use with an engine of this type is that shown in HOME STUDY MAGAZINE, February, 1898, article entitled "The Gas Engine," Fig 7. (*e*) The valve shown in the sketch will operate satisfactorily when the ratio of gas to air is 1:8 if, instead of taking in the gas as shown, it is admitted through the small holes in the seat. There should be 30 of these holes $\frac{1}{16}$ inch in diameter. The air inlet should be 1½ inches diameter. The governor may be so arranged as to throttle the gas supply, or it may be so

designed as to reduce the motion of the valve *V* by interfering with the valve stem *s*. The latter method is probably the better.

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(402) I have a flat-bottomed boat of the following dimensions length over all, 40 feet; width at top, amidship, 14 feet; width at bottom, amidship, 10 feet; widths at stern, 6 feet and 4 feet at top and bottom, respectively (*a*) How many tons will this boat safely carry? (*b*) How much water will it draw when loaded? (*c*) What horsepower will be required to propel it at a speed of 4 miles per hour against a 12-mile-an-hour current?

D H. G., Oro Fino, Idaho.

ANS.—(*a*) You do not mention the depth of your boat. Assuming it to be 4 feet, the displacement of water is approximately 1,440 cubic feet, when loaded to the water's edge. In other words, it displaces about 90,000 pounds of water. From this deduct the weight of the boat, and you will have the capacity in pounds, when loaded to the water's edge. If the depth is 4 feet, you can safely load it with 30 tons, including the weight of the boat. (*b*) At that rate it would draw about 3 feet of water. (*c*) To calculate the exact horsepower required to propel a boat requires an intimate knowledge of the shape of the boat and the lines upon which it is built. In the case of the boat under consideration, it would be impracticable to attempt to propel it at such a speed. Something like 400 horsepower would be required.

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(403) I would like to know the real cause of the slipping of a locomotive after steam is shut off. Is the cause the same with an eight wheeler as with a ten wheeler?

A. S., Tilbury.

ANS.—We do not believe that an engine will slip after steam has been shut off, unless it was slipping before, in which case the momentum of the moving parts might cause it to continue to slip for a short time after the throttle is closed. The steam exerts a force which tends to make the drivers slip; this tendency is resisted by the frictional resistance exerted between the wheels and the rails, which must be the greater of the two, as otherwise the engine would slip while steam is being worked. To make the drivers slip, therefore, the force exerted by the engine, tending to produce this result, must be made greater than the adhesive force between the wheel and the rail; or the adhesive force must be decreased below the other. The question is, does shutting off steam produce either effect? The force which tends to cause the drivers to slip after the throttle has been closed, is due to the kinetic energy of the moving parts, this force must be less than that previously exerted by steam, for the reason that the speed of the train immediately decreases when steam is shut off The slipping, therefore, if it occurs, must be due to a reduced adhesion between the wheel and the rail The reduced adhesion might be due to oil or water dropping on the rail when the steam is shut off, but this is not very probable. The only other way to reduce the adhesion would be to reduce the weight on the drivers, and no such effect is produced, of course, by simply closing the throttle. Very hard steel tires or very badly worn tires tend to make an engine slip.

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(404) I have seen the statement that there is a uniformity in electrical units which does not prevail in other sciences, and that in electricity there is one uniform system of units, which is used all over the world, while there are no less than *four* different and distinct heat units in use in this country and Europe, to the disadvantage of science, through the absence of a common standard. (*a*) Is this true, and if so, what are the four heat units? I saw a definition of one of them in the June number of HOME STUDY MAGAZINE. (*b*) Has any practicable scientific apparatus been devised for dispelling fog at sea, aside from torches or "flare" lights?

M. K., New York City.

ANS.—(*a*) The statement is true. The four heat units are: 1. The heat required to raise the temperature of one pound of water one degree Fahrenheit. 2. The heat required to raise the temperature of one pound of water one degree Centigrade. 3. The heat required to raise the temperature of one kilogram of water one degree Centigrade. 4. The heat required to raise the temperature of one kilogram of water one degree Fahrenheit. The first heat unit is called the British Thermal Unit, or B. T. U.; the third is called the Calory; the others have no specific names. The last heat unit is seldom or never used. (*b*) We do not know of any.

***

(405) Kindly give me instructions for making a 2-inch spark coil complete—diameter, length, wire, insulating compound, condenser, number of cells in battery, and a good contact-breaker for the coil.

R. R., Parnassus, Pa.

ANS.—See HOME STUDY MAGAZINE, October, 1897, Answers to Inquiries, No. 395. A contact-breaker is shown in the sketch below, in which *S* is a spring carrying a hammer (soft iron) *H* and platinum con-

tact *c*. *S* is insulated from the brass standard *A* by *K*, so that the path of the current when circuit is completed is shown by arrows. The soft-iron hammer is placed close to the core of the induction coil, and its oscillations are adjusted by means of the screws *e e*.

***

(406) Where can I get information as to process of manufacturing steel castings? Please give me any information you can and give names of the best books on the subject.

W R. W., Richmond, Va.

ANS.—The modern processes of making steel castings have been developed within quite recent dates, and so far as we know there are no books that give much information on the subject. The best available sources of information with which we are acquainted are files of such papers as the "American Machinist"

and the "Iron Age," in which are given reports of the proceedings of "The Western Foundrymen's Association," together with various articles and discussions by prominent foundrymen.

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(407) Is it possible to remove any of the material from the center of a round bar of iron without reducing the strength of the bar?

J. V. B., Binghamton, N. Y.

ANS.—No.

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(408) In HOME STUDY MAGAZINE, January, 1898, Answers to Inquiries, No. 553, you gave me a receipt for removing soot from stone. (*a*) What is Cabot's brick preservative, and where can it be obtained? (*b*) Also, mention one or two stone preservatives that you can recommend. I have not yet used your solution, but have previously used a solution composed of different proportions of the same ingredients; if you know of any other process, please describe it.

W. P. M., Halifax, N. S.

ANS.—(*a*) *Cabot's brick preservative* is, as its name implies, a preparation for protecting brickwork, on which it forms a waterproof coating. Its composition we do not know. It is applied with a brush, similarly to oil. The wall to be coated should be first washed with a weak acid solution, to remove any dirt and efflorescence on it. About 1 gallon of the preservative is necessary for each 200 square feet of rough brickwork, and a little less for the same surface of pressed brick. It is claimed that one coat makes as good waterproofing as three coats of linseed oil. The manufacturer is S. Cabot, Boston, Mass. (*b*) The *Ransome process* for preserving stone consists in applying a solution of silicate of soda or potash to the cleaned surface of the stone until it is saturated. After the surface has become dry, it is washed over with a solution of chloride of lime. Through chemical decomposition, the lime and silica form an insoluble lime silicate, which fills the pores of the stone, and also cements together the particles, thus increasing the strength and durability. Lime water may be used as a substitute for lime chloride, as then there is no soluble chloride of potash or soda to be washed away. *Sylvester's process* consists in the application of 2 washes, the first composed of Castile soap and water, and the second of alum and water. Use ¾ pound of soap to 1 gallon of water, and ½ pound of alum per gallon of water. Having cleaned the walls, which must be perfectly dry, apply the soap wash, boiling hot, with a flat brush. Allow 24 hours to elapse before putting on the alum wash, which need not be hot; let this dry 24 hours also. Continue to apply the solutions alternately until the walls are impervious to water. Probably only two coats of each will be necessary.

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(409) I have an ordinary magneto generator that generates 5,000 ohms. I use it on watchman clocks that have magnets that punch a sheet of paper indicating the time at which the magneto generator is turned. The arrangement works all right, but it is necessary to have 10 magneto generators for 10 stations. My idea is to dispense with nine of them and have only one for the watchman to carry to each station. I want to reduce the weight to 3½ pounds and still have the same result.

D. H., Chicago, Ill.

ANS.—We believe the Western Telephone Construction Co., 250 S. Clinton St., Chicago, have a few special generators with short armatures and field, built of two pieces 1¼ in. × ½ in. magnet steel, which will just about ring through 5,000 ohms, and would weigh about 2½ or 3 pounds.

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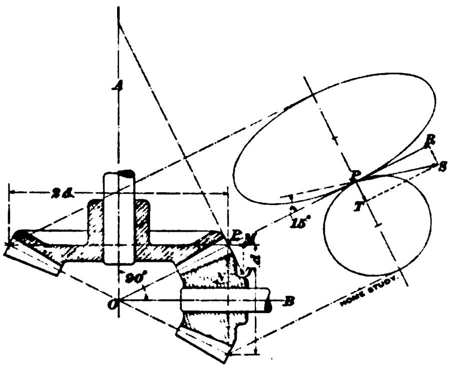
(410) (*a*) Kindly explain how to figure the end thrust on bevel-gear shafts. I have to transmit 250 horsepower by bevel gears from shaft *A* to shaft *B*, as in enclosed sketch: *A* makes 100 revolutions per minute, *B* 200. What is the end thrust of the shaft? (*b*) Is there any textbook on the subject?

P. B., Schenectady, N. Y.

ANS.—(*a*) Let a view of the gears be drawn on a plan perpendicular to the line of contact OP as shown, and let PR be the common tangent to the pitch circles. Then the line PS making an angle of 15° with PR is the line of action of the pressure between the teeth, assuming the teeth to be of the 15° involute form. Let the length PS represent the pressure exerted by the teeth of the larger gear against those of the smaller. This pressure may be resolved into two components: one, PR, along the common tangent, which tends to turn the gear, and the other



PT, which produces a pressure between the shaft and bearing. The component PT, which is perpendicular to OP, may be further resolved into two components, PM and PN (shown on gears) of which PM parallel to the shaft B produces the end thrust on B. It is easy to see that the other component PN is equal and opposite to the end thrust on the other shaft A. The thrusts are found as follows:

$$PT = PR \tan 15°.$$
$$PM = TP \sin TPN = PT \sin POB = PR \tan 15° \sin POB.$$
$$PN = PT \sin TPM = PT \sin POA = PR \tan 15° \sin POA.$$
$$\text{Tan } POB = \tfrac{1}{2};\ \text{whence, } \sin POB = \tfrac{1}{5}\sqrt{5} = .4472.$$
$$\text{Tan } POA = 2;\ \sin POA = \tfrac{2}{5}\sqrt{5} = .8944.$$
$$\text{Tan } 15° = .26795.$$

Substituting these values,

$$PM = .1198\,PR;$$
$$PN = .2396\,PR.$$

Letting d represent the radius of the large gear in *feet*, and N the revolutions per minute, the work done per minute by the force PR is $\pi d N \times PR$ foot-pounds; hence,

$$\pi d N \times PR = 33{,}000 \times \text{horsepower}:$$

or,

$$PR = \frac{33{,}000 \times \text{horsepower}}{\pi d N} = \frac{33{,}000 \times 250}{3.1416 \times 100 \times d} = \frac{26{,}260}{d}.$$

Substituting these values of PR,

$$PM = \frac{3{,}146}{d};\ PN = \frac{6{,}292}{d}.$$

Dividing by the radius of your large gear in feet, you will get the end thrusts on the shafts A and B. (*b*) We know of no textbook that pays special attention to this point. The solution given above for this particular example may be applied with slight modification to any other problem of a similar nature.

(411) Is it possible to get a steam siphon to siphon air out of a retort so as to produce 15 inches of vacuum? The retort is 25′ × 7′ 6″ × 7′ 6″; my steam pressure is 60 pounds gauge. I am told there is such a siphon in New York Quarantine.

ENGINEER, B. C.

ANS.—Yes. An ordinary steam injector will raise water to a height of 20 feet, and more than 15 inches of vacuum is required to do that. The size of the retort makes no difference in the degree of rarefaction obtainable. It requires, however, a longer time to exhaust the air from a large chamber than from a small one.

***

(412) Can you tell me where I can get a complete set of drawings of a modern locomotive, in which every piece is detailed, and its purpose explained?

H. Y. M., Hudson, N. Y.

ANS.—Although, doubtless, a request for a drawing of any particular detail would be favorably entertained by the majority of railroad and locomotive firms, yet we very much doubt if any firm would be willing to give you the set you desire. You will find practically what you want, however, in Meyer's "Modern Locomotive Construction," (Price $10.00), and in Forney's "Catechism of the Locomotive," (Price $3.00), both of which can be obtained from The Technical Supply Co., Scranton, Pa.

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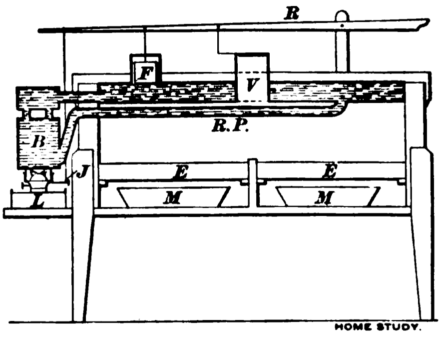
(413) I enclose a sketch of an incubator, in which *B* is the boiler, *J* the trip which cuts off the light from lamp *L*, *V* the valve, and *R* the regulator bar; *E*, *E* are the egg trays, *M*, *M* are the moisture pans, and *R P* is the return pipe. I wish to change the form of regu-



lator from the float *F* actuated by the expanding water to the thermostat similar to the one explained in HOME STUDY MAGAZINE for May, 1898, Answers to Inquiries No. 174, if that will do. Please explain where and how to attach a thermostat, and what kind of liquid to use in it.

J. H. F., Sykesville, Md.

ANS.—We can easily explain to you how the thermostat you refer to should be made, but we would rather advise you not to make one yourself, because this form of a thermostat is protected by letters patent. In any case, however, it is cheaper for you to purchase one from the manufacturers, and receive full instructions from them regarding its connections and adjustments. Write to The Powers Regulator Co., 40 Dearborn St., Chicago, Ill. We believe they can supply your wants.

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(414) I wish to obtain a secondary spark $\frac{1}{4}$-inch long; can I connect the primary coil to a small alternating dynamo *without* the make-and-break arrangement on a medical battery, and get the spark? If not, can I connect a small constant current dynamo in the same manner?

R. W. E., Alvarado, Cal.

ANS.—If the voltage of the alternating-current dynamo is not great enough to break down the insulation of the primary in the coil, nor the current so great as to cause undue heating, you can use the alternating dynamo without the circuit-breaking arrangement on the coil. The same may be said concerning the voltage and current of the direct-current dynamo, but of course with the direct current the circuit breaker would have to be used. The length of spark depends on the voltage obtainable in the secondary. You will require quite a high voltage to obtain a spark $\frac{1}{4}$-inch long. The insulation of the secondary of an *ordinary* medical coil will not withstand pressure enough for a $\frac{1}{4}$-inch spark.

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(415) (*a*) If the crankpin of a locomotive could be made to rub up against a board fence, what kind of line would it make on the fence? (*b*) Is the following formula correct for finding the horsepower of an engine:

$$\text{Horsepower} = \frac{\frac{P}{2} \times D^2 \times .7854 \times L}{33{,}000}$$

where P = steam pressure;
D = diameter of the cylinder;
L = distance the piston travels in feet per minute.

(*c*) What is the best book on physics, the price, and where can it be bought? (*d*) Would you recommend Joshua Rose's works as good, practical mechanical books? (*e*) Are there any better books on mechanics than the bound volumes of the Complete Mechanical Course of The International Correspondence Schools? (*f*) Is Kleine's Elements of Machine Design a good work? What is the size and price of the book, and where can I buy it?

J. P. S., Frackville, Pa.

ANS.—(*a*) It would draw a series of curves mathematically known as *curtate cycloids*. (*b*) If P is the *mean effective pressure* of the steam on the piston, as shown by an indicator diagram, the correct formula for horsepower is

$$\text{Horsepower} = \frac{P \times D^2 \times .7854 \times L}{33{,}000},$$

where L is the distance the piston travels in feet per minute, and D the diameter of the cylinder in inches. (*c*) The Elements of Natural Philosophy, by Elroy M. Avery, price $1.15, is an excellent elementary treatise on physics. Ganot's Physics, price $5.00, is a much more extensive and general work. These books are sold by The Technical Supply Co., Scranton, Pa., and will be sent, postage paid, on receipt of price. (*d*) Joshua Rose's works contain a great deal of information of practical value to any machinist or engineer. (*e*) The bound volumes of the Complete Mechanical Course of The International Correspondence Schools are prepared for the purpose of giving students of the schools the information required for their work as engineers, machinists, or draftsmen in the plainest and most concise manner possible, and in carrying out this plan the Schools have probably succeeded in furnishing much more of value to such men than could be derived from any other set of books that can be obtained for a similar price. (*f*) Kleine's Elements of Machine Design was written especially for the course in Machine Design at The Lehigh University. It is an excellent elementary work on the subject, and besides the usual matter given in such treatises, contains much special information on the design of gear teeth, together with several valuable tables and diagrams found in no other work. It is published by The Commenius Press, Bethlehem, Pa., price $6.00.

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(416) Kindly give me a rule for accurately determining the length of time required to heat different thicknesses of wood—round and flat—from the temperature of the atmosphere to 212° F., the wood being supported in a steaming box and surrounded by live steam from a boiler. In practice we allow one hour

per inch of thickness of wood, but would be glad to know of an accurate rule to go by.

L. C. E., New Orleans, La.

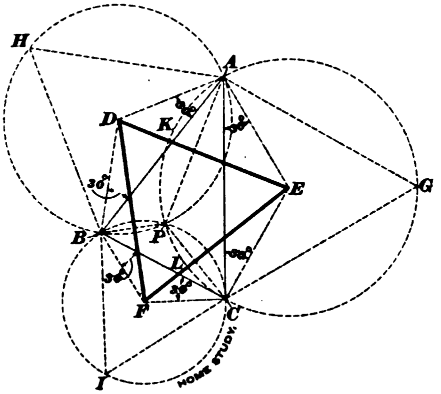
ANS.—We think it doubtful if such a rule has ever been formulated. The time required would vary considerably with kinds of wood, the construction of the box, the dryness of the wood, etc., and these varying conditions would make it almost impossible to formulate a rule that would have any practical value.

***

(417) Let ABC be any triangle. Draw AE and CE, making 30° with AC. Similarly, AD and BD with AB, and CF and BF with BC. Connect the intersections D, E, and F, and the triangle thus formed is equilateral. Please prove this.

T. G. H., St. Paul, Minn.

ANS.—Construct an equilateral triangle on each side of the given triangle ABC, and circumscribe



circles about each. The circumference of these circles meet at a common point, which can be found as follows: Suppose the circumferences AGC and AHB meet at P. Draw the lines AP, CP, and BP. Then, since the sum of the supplements of three angles whose sum is 180° is 360°, angle BPC is the supplement of I, because angle APC is the supplement of G, their sum being measured by one-half the circumference AGC; and angle APB is the supplement of H, their sum being measured by one-half the circumference AHB. Hence, the circumference BIC passes through P, because the supplement of I can only be inscribed in the segment BPC. From the centers of the circles, draw the lines DA, DB, EA, EC, FC, and FB, thus forming on each side of the given triangle an isosceles triangle whose equal angles are each equal to 30°. Join the vertexes of these isosceles triangles by drawing the lines DE, EF, and FD. Draw EP*; then, since DE is the perpendicular bisector of the common chord AP, arc $AK = KP$, and angle $AEK = KEP$; and, since EF is the perpendicular bisector of the common chord PC, arc $PL = LC$, and angle $PEL = LEC$. Therefore, angles $KEP + PEL = AEK + LEC$, or $2\,DEF = AEC = 120°$. Hence, $DEF = 60°$. In like manner, by drawing lines FP and DP, it can be proved that angles EDF and EFD are each equal to 60°, which proves that the triangle ABC is equilateral.

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(418) (a) What is the process by which mirrors are silvered by depositing the silver in solution and protecting the film with paint? This process is different from the old amalgam silvering, but is very useful. (b) What is a good way to test the purity of linseed oil? (c) How can I calculate the highest safe running speed of a sound cast-iron pulley? (d) How can a sample of lubricating oil be tested?

W. S. H., Portsmouth, Va.

ANS.—(a) There is quite a number of receipts; the following can be recommended, but it is rather expensive: Prepare a mixture of 3 grains of ammonia, 60 grains silver nitrate, 90 minims of spirits of wine, 90 minims of water; when the silver nitrate is dissolved, filter the liquid and add 15 grains of sugar dissolved in 1½ ounces of water and 1½ ounces of spirits of wine. Put the glass into this mixture, having one side covered with varnish, gum, or some other substance, to prevent the silver being attached to it. Let it remain for a few days, and you have a beautiful looking-glass. (b) Pure linseed oil should have a light yellowish-brown color. Its specific gravity, which is readily ascertained by means of a hydrometer, should be close to 0.93315 (a range from 0.925 to 0.945 is mostly allowed). On mixing carefully, in a beaker, equal volumes of the oil in question and red fuming nitric acid, a middle zone forms on the point of contact. This should be green, red above, and after some time the oil should color throughout red, if it is pure linseed oil. (c) It is generally assumed that the maximum allowable speed for the rim of a sound cast-iron pulley or flywheel is 6,000 feet per minute, corresponding to a stress of nearly 1,000 pounds per square inch in the metal of the rim. On this assumption the greatest allowable number of revolutions per minute N is given by the formula:

$$N = .0005236\,D,$$

where D is the mean diameter of the rim in feet. (d) Such large users of oil as the leading railroads and large iron and steel companies have determined, by experiment, the qualities of the oils best suited for different purposes, and buy their oils according to specifications which prescribe somewhat elaborate physical tests, such as viscosity, effect of cold, specific gravity, "flash" test, effect of exposure to atmosphere, etc. These tests require a somewhat elaborate and expensive outfit, and where they cannot be made, the only safe rule is to buy only from thoroughly reliable dealers, and study the wearing qualities and lubricating effects of their different brands when in actual use.

***

(419) (a) After a boiler has been cleaned, and the scale removed with potash or acid, is it a good plan, if the boiler is not to be used again for a long time, to fill the boiler with a solution of washing soda to prevent corrosion? (b) If the boiler were cleaned by using, say, the George W. Lord compound, would it *then* be well to fill it with water and soda?

A. H., Minden, Iowa.

ANS.—(a) A very weak solution of washing soda is an excellent preventative of corrosion in an unused boiler. It would be specially valuable in the case of a boiler which has been cleaned with acid. In such a case, the boiler should be thoroughly washed to remove the acid as completely as possible, and then filled with the soda solution. (b) We are not familiar with the Lord boiler compound, but in case it has been used, a thorough washing of the boiler, followed by the soda solution, will give good results.

***

(420) (a) What is the best book on compression ice machines and refrigerating machinery? What is the price, and where can I get it? (b) Where can I get large pieces of cork? W. B., Brenham, Texas.

ANS.—(a) We know of no book that we can recommend. Perhaps, "A Compend of Mechanical Refrigeration," by J. E. Siebel, might be of value to you. Can be ordered from us or from The Technical Supply Co., Scranton, Pa.; price $2.50. We also call your attention to the course in ice-making and refrigerating machinery offered by The International

* Line EP was accidentally omitted in making the figure.

Correspondence Schools, Scranton, Pa. You will find valuable information in "Ice and Refrigeration," published monthly by H. S. Rich & Co., Chicago, Ill.; \$2.00 per year. (*b*) Write to The Nonpareil Cork Mfg. Co., Bridgeport, Conn.

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(421) (*a*) How would you compute the volume of a portion of a right cone cut-off by a plane parallel to, but not passing through, the axis of the cone? (*b*) Is the same method used for cones other than right cones? T. P. P., Boston, Mass.

ANS.—(*a*) The volume of the portion referred to (which may be called a *conical wedge*) can be computed in the following manner: Add ⅓ of the square of the lesser abscissa to the product of the transverse

FIG. 1. FIG. 2.

diameter and the lesser abscissa, and multiply the square root of the sum by 21. To the product last ascertained, add four times the square root of the product of the transverse diameter and the lesser abscissa, and divide the sum by 75. Then divide four times the product of the conjugate diameter and the lesser abscissa by the transverse diameter, and multiply this last quotient by the former. Multiply the product by $(r - x)$ and divide the whole by 0.374. Should the questioner be unfamiliar with hyperbolic functions, there is a less complicated way in which to compute the approximate value of the conical wedge, as follows: The portions which, added to the conical wedge, would constitute a half cone can be considered as a prism. We have then (See Fig. 2),

$$\text{Volume} = \frac{\pi r^2 h}{6} - \left(\frac{\frac{h+m}{2} \times \frac{r+y}{2}}{2} \times r - n \right).$$

(*b*) The same operation can be applied to any cone with appropriate corrections for elevations.

***

(422) Please give the addresses of firms that can furnish me with machinery for manufacturing wax matches, straw-board, and cotton thread.
J. G., Key West, Fla.

ANS.—Write to Chas. A. Strelinger & Company, Detroit, Michigan. If they are not themselves dealers in match-making machinery, they will give you the information you require.

***

(423) (*a*) Could a turbine wheel be used successfully for raising water from a tiled and cemented well to a tank 30 feet above the level of the water in the well? The capacity of the tank is 300 gallons; it is not directly over the well, but 12 feet to one side. (*b*) If the use of the turbine is possible, what other machinery, pipes, and fittings would be required? At present I use a hand force pump, and I am opposed to the use of a windmill. The water is for my house supply. J. J., Derry, Pa.

ANS.—(*a*) A turbine can be used for pumping water from any kind of a well, provided there is a suitable supply of water for driving the turbine. (*b*) In addition to the turbine it will be necessary to have a suitable pump, with belts or other gearing to connect it to the turbine. It is probable you could connect your hand pump to a turbine without any change in the piping or fittings.

***

(424) Can I place a dry battery in a ¾-inch tube 3 inches long, that will heat a tube of platinum paper, ¼ inch in diameter, red hot in a few seconds? If possible, kindly give dimensions.
J. R., Baltimore, Md.

ANS.—In the first place, you will have trouble in constructing a dry battery in such a small tube unless a chloride of silver cell is wanted. The amount of current required to heat a piece of platinum paper of the size given above can not well be determined on account of the thickness of the platinum film not being known. Were the platinum rolled as thin as possible, it would carry more current than such a cell could give, with scarcely an appreciable rise in temperature.

***

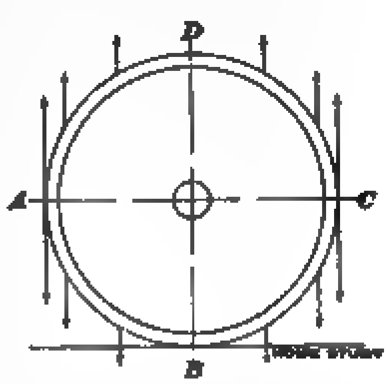
(425) (*a*) Why is the crank hanger bearing of a safety bicycle dropped below the line of the wheel axles from 1 to 3 inches? (*b*) Is there any gain of power in the use of the Ramsey, or swinging, pedals?
E. M. H., Palestine, Texas.

ANS.—(*a*) See HOME STUDY MAGAZINE, September, 1898, Answers to Inquiries, No. 344. (*b*) We do not know of any special advantage in swinging pedals, but an expression of opinion as to the merits or demerits of any patented article is out of place in these columns.

***

(426) (*a*) Is the centrifugal force in a rapidly revolving locomotive driving wheel counteracted by its weight pressing against the rail? (*b*) Will a crow-foot or a carbon-and-zinc battery drive a small ¼-horsepower electric motor? (*c*) Please give me the name and price of a book on the building of small boats, canoes, skiffs, etc., and tell me where I can get it. M. A. C., Sitka, Alaska.

ANS.—(*a*) To answer this question we must consider two possible cases: first, that of a wheel that is in perfect balance, and, second, that of a wheel that is not. Take the case of an eight-wheeled engine. Without entering into particulars, it may be stated that in some designs the rear drivers are in balance, and in others they are not. The main drivers are always out of balance, more or less, this being an unavoidable contingency. If the wheel is in balance, the same as a car wheel is supposed to be, the centrifugal force does not affect the rail, and so does not call for consideration. Every portion of the lower half of the wheel *A B C* has a tendency downwards, being the sum of the vertical components of the centrifugal forces generated in the various portions of the wheel, due to the latter's rotary motion (see arrows in sketch). So, also, the upper half *A D C* has an upward tendency exactly equal to the downward one just considered.



These two impulses neutralize each other, and there remains the original dead-weight of the wheel and its load pressing down on the rail. If the wheel is out of balance, by an amount *W*, the centrifugal pull of this weight when on the top center is not counteracted by any similar pull on the lower part of the wheel, and, therefore, the pressure on the rail, is, to this extent, diminished. When on the lower center, this force, due to *W*, acts with and increases the pressure on the rail, due to the dead load. (*b*) Yes, but not economically. (*c*) The best directions have appeared from time to time

in "Scientific American Supplement," Munn & Co., publishers, 361 Broadway, New York. Send 10 cents to them for each copy you desire.

***

(427) Please tell me how to construct, geometrically, an angle of 10°. L. L. G., Avon, N. Y.

ANS.—There is no strictly geometrical solution of the problem. The following construction is probably the best: Describe a circle; draw a radius $a\,b$, and, with the center b and radius $a\,b$, describe an arc cutting the circumference in c. Then the angle $b\,a\,c$ is 60°. Bisect the arc $c\,b$ geometrically, in d, and the angle $b\,a\,d$ is 30°; then, with the dividers trisect the arc $b\,d$, and the angle $b\,a\,c$ is 10°. There is no geometrical way of trisecting an angle. Another way to lay off an angle of 10°—or any other angle—is by using trigonometry. The tangent of 10° is .17633. Make $a\,b$, Fig. 2, 10 inches long. Erect a perpendicular $b\,c$ and make $b\,d$ 1.7633 inches; join $d\,a$. Then the angle $b\,a\,d$ is 10°.

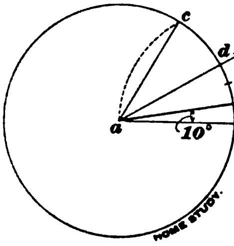


FIG. 1.

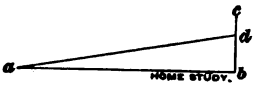


FIG. 2.

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(428) (a) Please name some good books on the design and construction of steamboats; also on navigation; give the price and tell me where I can get them. (b) Is there any school at which the above subjects are taught?

L. R. B. R., East Plymouth, Ohio.

ANS.—(a) There are several books on the construction of steamboats, among which "Naval Architecture," by Peake, can be recommended. The price is $1.40. On navigation, "Bowditch Practical Navigator" and Henderson's "Elements of Navigation" can be recommended. The price of the latter is $1.00. The above books can be obtained from The Technical Supply Co., Scranton, Pa. (b) Naval architecture and marine engineering are taught at Cornell University, Ithaca, N. Y., and also at the Massachusetts Institute of Technology.

***

(429) (a) Explain a method of case hardening without the use of bone. (b) How can steel be softened after being case hardened? (c) How should drills, chisels, etc., be tempered?

A. B. L., Wells, Minn.

ANS.—(a) Use prussiate of potash, 3 parts, and sal ammoniac, 1 part. Put the articles to be hardened into an iron box and sprinkle the mixture thoroughly over and around them; pack well with charcoal, and seal the box at the joints with fireclay. Put in the furnace and keep up a good steady fire (not too hot) for 20 hours. Quench in water, as usual. (b) Steel, in the ordinary sense of the term, cannot be case hardened. It will harden right through, when heated and quenched. Low grade steel, such as Bessemer, may be case hardened, although we should simply use a good wrought iron for any case-hardened parts we might require. However, case-hardened steel may be softened by making it a cherry red and cooling in limestone or smith's ashes. (c) Heat to a cherry red and cool out, quenching just the end, say the last ½ inch or so. Then rub the end bright with a piece of grindstone or a piece of emery paper on a stick. Then lay the article on a red hot bar and watch the colors appearing on the clean part. If a drill, quench right out when a pale straw color is obtained. If a chisel, wait for a darker shade to appear, something more of a dark straw. A little practice will enable you to catch the right colors.

***

(430) Kindly explain why an area of 8 inches square, when cut in the manner shown in the enclosed sketch and rearranged to form a parallelogram, has an area of 65 square inches? Where does the extra square inch come from? C. H. W., Causo, N. S.

ANS.—See HOME STUDY MAGAZINE, October, 1897, Answers to Inquiries, No. 363, for a similar question and answer, showing that the area of the parts is the same whatever their arrangement.

***

(431) (a) What is the best way to temper cold chisels, and the mainsprings of a gun? (b) How can copper be made very hard?

P. C. O., Beloxi, Miss.

ANS.—(a) Heat the chisel to a cherry red, quench the end (about the last ½ inch) in water, and then rub it bright by means of a piece of grindstone or some emerycloth on a stick. Then lay the end of the chisel on a red hot iron bar and watch the play of color on the chisel. As the heat flows from the bar to the chisel, the surface of the latter turns a pale straw color, and so on, gradually through darker shades of yellow, orange, brown, etc., to purple. When the chisel assumes a dark straw color, quench it right out. (b) By rolling or hammering.

***

(432) Is there any book published that contains information on boiler repairing? I want information on patching, riveting, and brazing; also, on plugging the tube holes in tube sheets where it is necessary to remove two or three tubes, by welding a short piece of the tube on one end and expanding in the tube sheet. I have several works on boiler construction but they do not contain the information I want.

J. I. S., Denver, Col.

ANS.—We can recommend "Boiler Making" by Ford, price $1.00, and "A Treatise on Steam Boilers" by Robert Wilson, price $2.50. Either can be had from The Technical Supply Co., Scranton, Pa.

***

(433) (a) Please give formulas for finding the hauling capacity, tractive power, and adhesive power on a level road, and hauling capacity on a grade of 100 feet per mile for the following locomotive: Diameter of cylinder, 16 inches; stroke, 24 inches; steam pressure, 140 pound gauge; four driving wheels, 62 inches in diameter; weight on the four drivers, 48,000 pounds; weight on truck, 26,000 pounds; total weight of engine, 74,000 pounds. (b) Also, give pull at drawbar to move a box car of 30 tons capacity whose weight when loaded is 90,000 pounds. (c) Give pull necessary to haul at a speed of 35 miles per hour. R. F. P., Houston, Tex.

ANS.—(a) The *hauling capacity* and the *tractive force* are, as you know, closely related. The term "capacity of a locomotive" is generally used to denote the limit load that it can handle properly over a given road. Granted sufficient tractive force, the *capacity* of the engine depends on the steaming capacity of the boiler. An engine may be abundantly powerful as regards its cylinder power and the adhesion, and yet get stalled on a grade through inadequate steam supply. We will now consider the case you present. *Adhesive power*, or *adhesion*: The coefficient of adhesion varies with the state of the rails—whether wet, dry, sanded, etc. We will take it as being 25 per cent.; that is to say, one-fourth of the total load on the drivers will be regarded as available for traction. Our adhesive weight, then, is $.25 \times 48,000 = 12,000$ pounds. *Tractive force*: The average tractive force during one

revolution of a locomotive having two high-pressure cylinders, is expressed by

$$T = \frac{d^2 PS}{D},$$

where d = diameter of cylinder in inches;
S = length of stroke in inches;
D = diameter of drivers in inches;
P = mean effective pressure in lb. per sq. in.

Mean effective pressure: Consider the speed in the present case over a level road to be 50 miles per hour; with a 30-per-cent. cut-off and 270 revolutions per minute, the M. E. P. will be about 47.5 pounds. Then

$$T = \frac{256 \times 47.5 \times 24}{62} = 4{,}700 \text{ pounds, say.}$$

Deduct 8 per cent. for the internal resistance of the engine, and we have remaining 4,324 pounds. On a level road the resistance per ton (2,000 pounds) of train at 50 miles per hour, may be taken as 14½ pounds. Then the total load hauled $= \frac{4{,}324}{14.5} = 298$ tons. The total weight of the engine is given as 74,000 pounds; if we allow 46,000 for the tender in average working condition, the total weight of engine and tender is 120,000 pounds, or 60 tons. Thus, $298 - 60 = 238$ tons is the weight of train that can be satisfactorily handled by the given engine on a level track, at 50 miles per hour, assuming sufficient boiler capacity. On an up grade of 100 feet to the mile, the load will, of course, be much less. Assume the speed to be 30 miles per hour on this grade. Then the M. E. P. at 160 revolutions, and a 50-per-cent. cut-off, will be about 67.5 pounds. Then,

$$T = \frac{67.5}{47.5} \times 4{,}700 = 6{,}680 \text{ pounds, say.}$$

92 per cent. of this = 6,146 pounds.

Resistance of train at 30 miles per hour may be taken as 9½ pounds per ton; resistance due to grade as 38 pounds. Then total resistance per ton = 38 + 9½ = 47½ pounds; tractive force = 6,146, whence tons hauled $= \frac{6{,}146}{47.5} = 130$, say. Engine and tender weigh 60 tons; therefore, train may weigh 70 tons. (*b*) The force required to *start* a car is very much greater than that required to keep it in motion after speed is attained. To start a box car weighing, with load, 90,000 pounds, a pull of from 800 to 900 pounds will be required. As soon as a speed of, say, 5 to 10 miles per hour is reached, the pull will drop to about 200 pounds. After that the pull will again increase, due to wind resistance. (*c*) About 500 pounds.

***

(434) How can a piece of iron or steel be heated to a certain temperature and kept at that temperature for any desired length of time? Can it be done best by electricity or a coke fire?

C. F. H., Cleveland, Ohio.

ANS.—We have never had any experience in such a matter. Electricity would be most suitable if you could get a constant strength of current. If you use a coke fire, we advise you to keep the article (if not too large) inside a piece of iron pipe in the fire. The pipe being kept red hot, the piece inside it will be red hot also, and will remain clean. It will also be visible, and you will be able to tell from its color whether or not its temperature is kept constant.

***

(435) (*a*) How can I make a battery for a table lamp? (*b*) How many cells would be required for a 90-volt lamp? (*c*) What voltage is generally used?

C. E. B., Dayton, Ohio.

ANS.—(*a*) The best type of cell for your purpose will be a bichromate. Each cell is provided with two carbon plates, between which, but not touching, is suspended a plate of zinc. This may be secured to a sliding rod held in a frame in such a manner as to allow of the zinc being drawn up out of the electrolyte when not in use. A common form of bichromate battery consists of several jars in a row, having their elements all supported from a wooden crossbar. With this arrangement, all the carbons and zincs together may be lifted from the solution when desired. The electrolyte is composed of 3 parts of potassium bichromate, dissolved in 18 parts of water, to which is added 4 parts of sulphuric acid. (*b*) For a 90-volt lamp you will require from 45 to 50 cells. (*c*) It would be better to use a lamp of lower voltage, say about 25 volts. Buy one of standard make, so that you may renew it when necessary.

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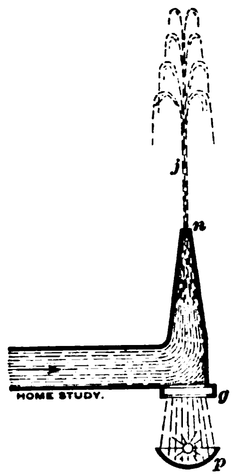
(436) Will you please answer the following questions in your Answers to Inquiries? (*a*) Please describe the construction of an electric fountain, using a diagram. (*b*) I would like to obtain the names of all electric-lighting and power stations using water-power and situated in America, and also some information about the construction of these plants. Will you kindly give me a reference for obtaining this information.

F. O., San Francisco, Cal.

ANS.—(*a*) The principles of construction are shown in the figure. A transparent window *g* is placed immediately opposite the opening in the fountain nozzle *n*, and the rays from an arc or a powerful incandescent lamp are projected through the window and into the path of the jet *j*. A portion of the rays are reflected from the surface of the stream, producing an illumination of the falling drops. Colored screens are usually inserted between the window *g* and the projector *p*, so as to vary the effect. These screens may be so arranged as to move by clockwork, changing periodically. Magnificent effects may be obtained with combinations of various colors by using, say, a yellow and a red screen together, producing orange, etc. Within the base of the great electric fountains, so familiar to visitors at the World's Fair in 1893, there was a large operating room containing the lights and the screen mechanisms. Each fountain was connected to the other by telephone, so that similar effects might be produced in both fountains at once. (*b*) Write to any one of the following for lists of names. The data, we judge, can be obtained only from the stations themselves, Boyd's City Despatch, 16 Beekman St., New York, N. Y.; The Rapid Addressing Machine Co., 314 Broadway, New York, N. Y.; The Trow Directory and Publishing Co., 124th St. and University Place, New York, N. Y.; The Howe Publishing Co., Philadelphia, Pa.



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(437) Wherein does Roman architecture differ from that practiced by the Greeks, and what relationship may be said to have existed between the Roman and Greek orders?

B. R. L., Chicago, Ill.

ANS.—In ancient Greece, construction and architecture were the same thing; in Rome, they were considered as apart from each other. The keynote of Roman construction was the arch, which they

inherited from the Etruscans—the great engineering race of ancient Italy. The Greeks never used the arch, the lintel being used exclusively in preference. Other differences, both constructive and artistic, are best studied in connection with the character of the Romans themselves. *First*, their practical and material character made itself felt in the demand for magnificence in art, as well as for luxuries in life, while the Greeks were well contented with the simplicity and purity of abstract beauty. In Greece, the temple attained the highest artistic development; in Rome, the palaces, the baths, and amphitheatres received most attention. *Second*, their political character, imperial and undemocratic, demanded the satisfaction given by numerous large and impressive buildings to keep pace with the foreign conquests. A single tier of columns would not suffice; hence, the orders were superimposed according to a regular system, and were used merely as decorative features. This the Greeks never would have done. *Third*, their cosmopolitan, or world-wide empire, made necessary the erection of buildings all over the known world. For this purpose a material was needed that could be obtained anywhere, and could be produced by the most unskilled labor. Hence, they used cement concrete, in solid arch and vault construction, and incrusted these skeletons with fine marble or stucco. The Greek marble walls were solid throughout. With the use of unskilled labor in the endless repetition of forms in the immense Roman buildings, came the natural modification of the Greek detail for greater ease of carving and for greater richness of effect. To the first end, all moldings were made to conform to circular arcs, the sharp edged channelings were omitted from the Doric column, the Ionic capital was much simplified, and all proportions were reduced to a system. Of course, the subtle refinement of the Greek lines was lost, and the result was still better prepared for the Roman ideals by the introduction of carved ornament in the friezes of nearly all the orders. The foliated running scroll was developed for this purpose by the Roman artists, and it was no mean invention. Thus, the relationship of the Roman to the Greek orders is one of free translation. It was a case of adaptation to new conditions. It is no reflection upon Roman art that it was modified from the purely beautiful forms of Greece to suit a less cultivated taste. Indeed, it was done remarkably well. Greek art was impossible in Rome, as it is even now impossible to us. We are the Romans of our day.

***

(438) Will you kindly tell me, through your Answers to Inquiries columns: (*a*) What is the chemical composition of white lead? (*b*) How is it manufactured? (*c*) Why does it turn gray on exposure to the air? (*d*) What is it chiefly adulterated with, and how may such adulterations be detected? (*e*) Is old white lead as good as new? (*f*) How may the quality of white lead be determined? J. W. S., Camden, N. J.

ANS.—(*a*) White lead is a carbonate of metallic lead, with variable proportions of lead hydroxide, and is soluble in acids and partially soluble in water. (*b*) In the process which is still maintained to produce the best quality of white lead, and which is known as the "Dutch Process," the purest metallic lead is cast into perforated disks, 7 inches in diameter and ⅛ of an inch thick; these are packed into earthenware pots about 15 inches high, and to each pot is added a small amount of acetic acid. The pots are then piled into bins 40 feet square, the whole being covered with spent tan bark and let stand for about three months. At the end of this time, the metallic lead becomes converted into white carbonate. The quantity of lead thus converted into white lead seldom exceeds 65 per cent. The white lead is separated from the metallic lead by a revolving screen, and is then ground to a fine powder, and made into a paste by adding 10 per cent. of linseed oil to it. This forms what is known, commercially, as *white lead in oil*, and is used for the basis of all paints. There are many other processes by which white lead may be manufactured, tending towards quickness and economy. White lead may also be produced by precipitation, though it is generally considered inferior to that prepared by corrosion; it is wanting in density and absorbs more oil, but does not require grinding. (*c*) White lead, if exposed to the air, soon becomes gray by the action of the sulphureted hydrogen in the air, as well as by the sulphurous fumes from chimneys, etc., which unite with the moisture in the air, and form free sulphuric and sulphurous acids; these act upon the lead, producing a grayish-black precipitation; this causes the gray appearance of woodwork, etc., painted with this compound. (*d*) The adulteration of white lead is frequently accomplished by mixing with it such substances as sulphate of barium, sulphate of lime, whiting, chalks, etc. These substances do not readily combine with oil, nor do they successfully protect the surface to which they are applied. The most common adulterant is sulphate of barium, commonly known as *barytes*, which is a dense, heavy, white earth, very similar in appearance to white lead. This substance absorbs little oil and may be easily detected by the gritty feeling it produces when the paint is rubbed between the fingers. (*e*) White lead improves with age; old white lead goes further and lasts longer than the new, and it is also less liable to turn yellow. (*f*) The quality of white lead may be tested by a very simple operation, which is, in the case of dry white lead, to digest it with nitric acid, in which the white lead will readily dissolve in boiling. When it is desired to test white lead, ground in oil, the oil should be burned off, and the residue treated with nitric acid.

***

(439) I wish to install an efficient heating and ventilating plant in a three-story-and-basement brick school building, and desire to ask what method of heating and ventilating you recommend? What is your opinion of the dry system of closets in connection with ventilating systems? D. W., New Orleans, La.

ANS.—We would strongly advise you not to consider any proposition or plan for heating which is in any way connected to, or allied with, any sewerage system, either "dry closet" or otherwise. We particularly wish to warn you against that dangerous humbug called the "dry-closet system of heating and ventilating." A large number of these systems have unfortunately been installed in many *otherwise* first-class schools, but they are now being rapidly removed. We believe the time is not far distant when state laws will prohibit the use of dry-closet systems. There is only one way to properly warm and ventilate a large school building, and that is by the use of a fan. All gravity systems of ventilation are, and always have been, utter failures. Your best plan is to arrange the system as follows: Provide a centrifugal fan; set it in the basement, and supply it with fresh air from the outside atmosphere. Build water-tight ducts or air tunnels underground to connect fan to the vertical flues. At the base of each vertical flue, place an indirect steam radiator, and arrange a mixing damper to be operated and controlled from the room to be warmed, so that the teacher can easily mix the hot and cold air, and thus regulate the temperature of the room without changing the volume of the ventilation. Build a set of vent flues, one or two for each room. Use a water-tube boiler of any approved make, and run it at a pressure high enough to work the fan engine.

Let the exhaust steam blow into the indirect heaters, and provide a reducing-valve connection with the boiler, so that low-pressure live steam may blow into the indirect heaters if there is not enough exhaust steam to supply the heat. Run a separate exhaust pipe up through the roof and furnish it with a back-pressure valve.

***

(440) Will you please answer the following questions in Answers to Inquiries? (*a*) What is the rule for calculating the internal resistance and consequently the current on short circuit of a bichromate-of-potash cell? (*b*) Is it possible for one of these cells to furnish a current of 25 amperes on short circuit? (*c*) If so, what size plates should be used? (*d*) Will a ¼-horsepower motor drive a boat 12 feet long by 42 inches beam at a speed of 6 miles per hour, and carry 2 passengers? (*e*) What size of 2-bladed propeller should be used for a boat of this size and speed? J. V. C., St. Louis, Mo.

ANS.—(*a*) The following formula is a convenient one for use with a voltmeter and a known resistance.

Let r = the resistance of the cell;
R = the known resistance;
E = the voltage of the cell on open circuit;
e = the voltage of the terminals when the resistance R is in circuit;

Then,
$$r = R \times \frac{E - e}{e}.$$

Quick readings should be made in order that the results may not be affected by the slight depolarizing action of the current. Also, the voltmeter should have a resistance which is high when compared with the known resistance. (*b*) It is possible when the zinc plate is large enough. (*c*) As much depends upon the distance between the electrodes as upon the size of the plates. To insure good results, use a plate with an active surface of at least 200 square inches, say a plate 10″ × 20″, or two plates 10″ × 10″. One plate will answer if there is a carbon on each side of the plate, at least as large as the zinc, making both sides active. (*d*) No, you should use a ½-horsepower motor. (*e*) 12 inches diameter, 14 or 15 inches pitch.

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(441) (*a*) Will you kindly give some information regarding the Thompson recording wattmeter? We have some that will not start on a 1-light or 2-light load, the meters being for 5 amperes and 220 volts. We have cleaned the commutator and brushes, removed the train, examined the jewel and oiled the lower one a little; all connections are good, and still it fails to move. What else can be done? (*b*) What causes one-half of a double-pole switch to warm up? (*c*) How many volts are considered dangerous to life? (*d*) Can a person get the full E. M. F. by taking hold of the conductors when they are connected? I. C. R., Preston, Minn.

ANS.—(*a*) In cases of this kind, the trouble is generally found in the jewels. The lower jewel may be too light, and the hardened-steel point may be forced into the jewel, causing it to bind and sometimes to crack. Adjust the jewels,and all the mechanism, so that there will be the least possible friction; then, if the meter does not work, it should be tested for a weak field. The field may be short-circuited, thus cutting out a part of it and weakening it so that with a 1- or 2-light load it does not have power enough to overcome the friction. (*b*) If a double-pole switch heats on one blade only, the trouble must be that there is poor contact between the blade and the clips. (*c*) It is not the voltage that is injurious. The injury depends upon the amount of current received, and the voltage must be sufficient to force the current through the resistance of the body. People have been killed by street car currents at less than 500 volts. At other times, persons have received alternating currents of high frequency (16,000) at 1,000 volts with no more injury than badly burned hands and feet. A person can take the shock from an electrostatic machine and feel no bad effects whatever, when the voltage of said machine runs up into the thousands. See, also, HOME STUDY FOR ELECTRICAL WORKERS, July, 1898, Answers to Inquiries, No. 204. (*d*) Yes; a person would be subjected to the full E. M. F., but he would receive a great or small current according as the resistance of his body was small or great compared with the resistance of the regular circuit.

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(442) Can you give me some practical method of determining the thickness of walls of buildings, that is, some proportion of thickness to height and length? R. T. B., Manhattan, Kan.

ANS.—We can give no practical rule for determining the relation between the height and the thickness of a wall. Obviously, such a rule should be founded upon experiments; but, so far as we are aware, no tests have been made upon the walls of actual buildings. A few are on record of the crushing strength of brick and stone piers, but the results are evidently not applicable to walls.

The absence of such tests consequently renders the subject very uncertain. A wall should, for stability, have a certain ratio of thickness to height. In the large cities, this is fixed by law; but there are great differences between the widths required in various places. In New York, for instance, the thickness of wall in the first story of a 4-story warehouse must not be less than 16 inches, while in Memphis, Tenn., the width must be 27 inches. Taking the New York law as a typical example, we find that no wall must be over 50 feet in height without an increase in thickness of the lower portion. The following is a tabulated summary of the law, relative to dwelling-house walls. Warehouse walls are about 4 inches thicker than those of dwellings of the same height.

Total Height.	Graduated Thickness.									
	H.	T.	H.	T.	H.	T.	H.	T.	H.	T.
35′	23′	8″	12′	12″						
50′			50′	12″						
60′			50′	12″	10′	16″				
75′			50′	12″	25′	16″				
85′			25′	12″	40′	16″	20′	20″		
100′					25′	16″	40′	20″	35′	24″

From the above table, it will be seen that the thickness of the lower portions varies from $\frac{1}{35}$ to $\frac{1}{50}$ of the height, while the height of these sections is from $\frac{1}{3}$ to $\frac{1}{2}$ the total height of the wall. Taking an average of the figures, it is found that the thickness should be at least $\frac{1}{45}$ of the height. It must be understood that these results apply only to walls which are well braced by floors, etc.

A formula, known as "Rondelet's Rule," to obtain the thickness of walls at any height, has been proposed, but it gives much greater results than are used in ordinary practice. The formula is:

$$T = \frac{L\,H}{N\sqrt{L^2 + H^2}},$$

in which H = height;
L = length between buttresses, or cross-walks;
T = thickness;
N = constant.

The value of N is 10 for brick, 12 for finely cut stone, 8 for imperfectly cut stone, and 6 for rubble. For example, find the thickness of a brick wall 40 feet long, and 30 feet high. Substituting in the formula, we have:

$$T = \frac{40 \times 30}{10\sqrt{1{,}600 + 900}} = 2\tfrac{2}{5}\text{ ft.} = 2\text{ ft. }5\text{ in., nearly.}$$

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SCIENTIFIC KNOWLEDGE IN DAILY LIFE.

W. H. Booth.

Its Usefulness—Permeability of Cast Iron and American Complexions—A Beautiful Experiment Demonstrating the Diffusive Power of Gases.

IT IS quite a common thing to hear young people ask what use scientific knowledge is unless one is going in for a career of chemistry, or of engineering, or of medicine. Possibly the state of mind that this question indicates arises from the too frequent assumption that scientific knowledge is separated from other kinds of knowledge by a sharply defined border line. Now, such is not the case. There is no border line to any kind of knowledge. Even the terms *virtue* and *vice* describe no separate and distinct line of conduct. For example, it may be healthy and virtuous for a man to plunge into cold water, swim vigorously for two minutes, rub down, dress, and walk briskly home. If this same man were to prolong his stay in the water to seven minutes, or if the habit were indulged in at all by another man, it might be a vice, because harmful.

What to me is scientific knowledge may be mere A-B-C to some professor of science whose knowledge is wider and deeper than my own; but so far as my little knowledge of facts goes it is good, though more knowledge is better, for the more one learns, the more safely can one make use of knowledge previously acquired.

Take, for example, the administering of drugs of a poisonous nature. For tonic purposes doctors sometimes give a vegetable poison called *digitalis*. The action of this drug is cumulative, and in the end it is liable to cause sudden collapse and death. Simply to know the drug as a tonic might cause its use to be dangerously extended. A little knowledge is a dangerous thing. It therefore behooves one not to be too rash in applying knowledge right up to the borders of our little share of it. It is better to leave a margin beyond the area in which we exercise, only encroaching upon this margin as we are able to extend our knowledge into the next lot. But, as we shall always be envious of our uncropped margin, we shall be urged to acquire knowledge beyond it, so as to bring the margin into use. We can never learn too much; nor must we think we cannot usefully apply scientific knowledge in every-day life. An example will best show how the knowledge of a scientific fact may be put to good account:

It is generally admitted that English people have fresher complexions than Americans, and the cause is said to be that open fireplaces are used in England, and closed stoves in America, and that the open fireplace gives better ventilation. Undoubtedly it does give better ventilation, and good ventilation is healthful; but we must not at once assume this to be the whole cause of the difference between American and English complexions. There is another cause which is not generally recognized. The American stove is generally made of cast iron. Now, it is known to chemists and to students of physics that many substances that are usually looked upon as impermeable are by no means impermeable to some gases. One of these substances is cast iron, which is permeable to the gas known as carbonic oxide. This gas, the chemical symbol for which is CO, is a combination of carbon and oxygen, and is given off by slow-burning fires, that is, fires in which the supply of oxygen is insufficient to cause the complete combustion of the coal. It may be seen burning with a pale-blue flame over almost any coal fire. This gas, which

is poisonous, will pass readily through red-hot cast iron, and to a less extent through cooler plates. If, then, a cast-iron stove becomes red hot, the carbonic oxide generated by the fire within the stove will leak through the hot plates and poison the air of the room.

Medical chemistry tells us that this gas has a peculiar action upon the red corpuscles in the blood, by which it destroys them. Absence of red corpuscles from the blood constitutes anemia. Here, then, we have an explanation—or a partial one—of the unhealthy effect of the closed stove; and it is more important to know this than it is to know that bad effects result from over-dryness of the air or from bad ventilation, to which causes the muddiness of many American complexions are generally attributed. Now, if it were stated to some people that the carbonic oxide formed inside the stove leaked out in the above manner, they would tell you that if you bored a hole in the side of the stove, air would rush in at the hole, from which they would argue that the tendency for the outside air to rush inward would sweep back the leaking carbonic oxide. But this by no means follows. There is another property of gases (of which, indeed, the leakage of carbonic oxide through cast iron is but an example) which must be known in order that a correct explanation may be made. All gases have a tendency to spread, or expand, in all directions, and they will readily traverse porous substances in their endeavor to do so. If we take a vessel, divided by a central division of porous pot or dry bladder, and fill one end with one kind of gas and the other end with another kind that has a different specific gravity, both gases will pass through the division plate, but they will not pass through it at the same velocity; the lighter gas will travel the faster, and, if a delicate pressure gauge be attached to each end of the vessel, it will be seen that in one end the pressure rises, while in the other it falls.

An interesting experiment can be cheaply made to demonstrate this diffusive action: Take a porous pot—*a* in the figure—and close its top with a rubber stopper, through a hole in which insert a glass tube *c*. Stand the pot on a stool as shown, and immerse the end of the glass tube in a glass tumbler *d*; fill the tumbler with water previously colored red or blue, so as to be more readily seen. Over the pot invert a large jar *f* as shown in the figure. Between the pot and the jar push up an india-rubber tube *e* and connect the tube to a gas jet; turn on the gas and let it escape into the jar. Do all this in daylight, away from a light or fire. As soon as the gas is turned on, bubbles will begin to escape from the lower end of the glass tube *c*.

These bubbles are air forced out of the porous pot by the lighter hydrocarbon gas which forcibly diffuses through the porous substance of the pot. The pressure is actually raised inside the pot, although all we have done has been done without any mechanically generated pressure, and in open air. After this has gone on for some time, the bubbles will cease to come, and the porous pot will be filled with the gas.

Now for a second and more striking experiment: Turn off the gas and remove the jar *f*, leaving the porous pot fully exposed. The light gas inside it now struggles to get out again, and diffuses back through the pot so forcibly that it leaves behind it a partial vacuum, as a proof of which the colored water in the tumbler rises in the tube and may even enter the porous pot itself. And now, to apply the knowledge we thus gain to the stove: The internal carbonic oxide is hot, and is therefore lighter than the cooler air

outside, which is of nearly equal weight at the same temperature. Even if air had the power to diffuse through iron, the lighter internal gas would escape outwards and, passing through the hot plate, would poison the air of the room.

As compared with an English open fireplace, the American stove is so much more economical of fuel that its use is likely to continue. It is therefore desirable that its construction should be such as to avoid the heating of the plates to the extent of redness, at which temperature the carbonic oxide so easily leaks through. In the second place, it is possible to so design a stove that the external surface is covered by an outer casing, through which a current of air may traverse, sweeping up the poisonous gas and conveying it to a chimney. This would waste some heat, but it would assist ventilation; then the flue pipe might be of *wrought-iron* or *steel* plate, so as to radiate heat and not allow its poisonous contents to escape. The relative tendency of gases to diffuse is as the square roots of their specific gravities. Thus, hydrogen diffuses nearly four times as quickly as air, which is nearly 16 times heavier; applying the rule to gases which are expanded by heat, it follows that the hotter we allow a stove to become, the more rapidly will the carbonic oxide diffuse outwardly, for it will be reduced in density, and will have a more permeable substance to traverse.

If it were not for the diffusive property of gases, we should be liable on a calm day to be asphyxiated by the gradual accumulation at the earth's surface of the carbonic acid which exists in the atmosphere in the proportion of about four parts in ten thousand. The separation and fall of this heavy gas from two miles depth of the atmosphere would cover the tallest man, and in still weather all valleys and low places would be uninhabitable. This same property of diffusion assists to maintain the air of a closed room in moderate condition. Most materials of buildings—brick, mortar, plaster, etc.—are permeable; so are sandstones; but some stones are almost impermeable to gases—certain limestones and granites, for instance. Brick is thus a good material to use for the walls of a house. Where porous materials are not used, more special openings are needed for ventilation than where the walls are made of permeable materials.

THE CORLISS VALVE GEAR.

Carl G. Barth.

CHARACTERISTIC FEATURES: THE OSCILLATING VALVES, WRISTPLATE, RELEASING MECHANISM, AND CLOSING APPARATUS—COMPLETE CYCLE OF OPERATION—RANGE OF CUT-OFF.

THOUGH the Corliss valve gear is probably the oldest invention that enables an engine to utilize the expansive power of steam to the full extent of economy, it still holds its own in competition with a large number of much simpler mechanisms that have from time to time been placed on the market.

As a consequence, there are at present few, if any, of the manufacturing states of the Union in which there is not one, or more than one, concern that builds a Corliss engine in one form or another; indeed there are said to be, in all, more than eighty such establishments.

Whether or not this continued popularity of the Corliss valve gear is deserved, we will not attempt to discuss here, confining ourselves rather to the statement—as to the truth of which there is no doubt—that many engines of this type are installed under conditions for which some simpler and cheaper type would give fully as high economy and be more suitable generally.

However, the Corliss valve gear is in itself an interesting piece of mechanism, and, as such, deserves to be fully described and explained; so we have prepared the following illustrations and descriptions of a Corliss valve gear that embodies, among other special features, a recently designed modification of the Reynold releasing mechanism.

The most characteristic features of the Corliss valve gear are four in number:

1. The four *oscillating* valves. Two of these are placed at each end of the cylinder—the one (the *admission* valve) controlling the admission of the steam, the other (the *exhaust* valve) controlling the liberation of the expanded steam.

2. The *wristplate*. This is an oscillating plate or disk, actuated by the eccentric on the main shaft and in turn communicating motion to the four valves.

3. The *releasing mechanism*, of which the governor forms a part. This disconnects an admission valve from the wristplate when the supply of steam is to be discontinued through its port.

4. The *closing apparatus*. This, immediately upon the release of an admission valve, brings the valve back to its closing position.

Referring now to the illustrations, Fig. 1 represents an end elevation; Fig. 2, a side elevation; Fig. 3, an end section; Fig. 4, a complete longitudinal section of a Corliss engine cylinder; while *C*, *D*, and *E*, Fig. 5 are a series of partial longitudinal sections, showing various simultaneous positions of the piston and the four valves; Fig. 5, *A*, is a diagram showing the various simultaneous positions of the crank-pin and the center of the eccentric that would, if it were not for the *angularity* of the various connecting-rods, correspond to the piston positions in Fig. 4 and Fig. 5, *C*, *D*, and *E*. Fig. 5, *B*, is an ideal indicator diagram from the *head end* of the cylinder, arranged on the page so as to readily draw attention to the relations between its various characteristic points and the simultaneous positions of the piston and the valves of the engine.

The wristplate *W*, Figs. 1 and 2, is seen to be mounted on the journal-shaped end of a bracket *W′* that is securely bolted to the side of the cylinder. It is, on the side facing the cylinder, provided with four hubs *w*, into which are forced as many steel pins, whose projecting parts serve as points of attachment for the connections through which its motion is communicated to the valves. The wristplate is also provided with a larger hub *w′* which is bored to receive and act as a bearing for the projecting journal of a swivel *S* through which it indirectly receives its own motion from the eccentric. The intervening members between the eccentric and this swivel are: The *eccentric rod*, the *rocker-arm*, and the *wristplate rod R*.

By means of the rocker-arm the horizontal motion of the eccentric rod is intensified at the wristplate rod, the resultant motion of the wristplate being, however, essentially the same as if this rod were actuated directly by an eccentric of a proportionally greater throw. The eccentric, the path of whose center is represented by the small circle in Fig. 5, *A*, is, in fact, not the actual one, but the *ideal* one, that would produce the same effect as the real eccentric by having its rod extend directly over to the wristplate swivel *S*. It will be seen that the wristplate rod is

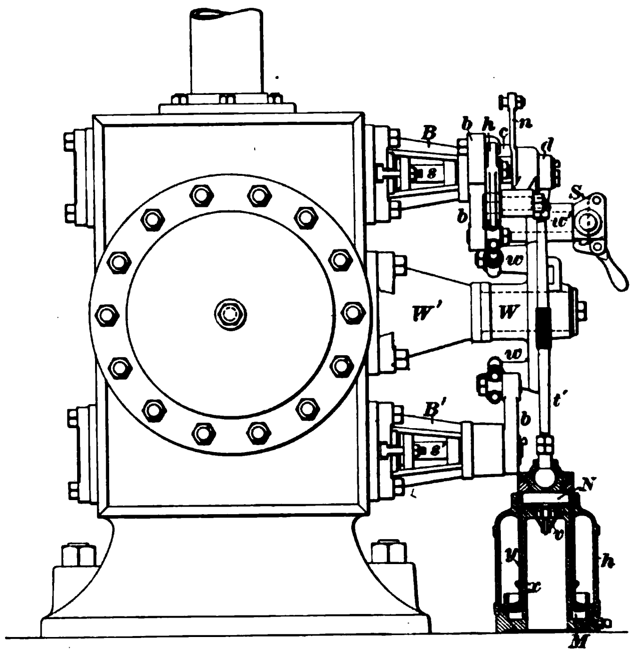


Fig. 1.

coupled to this swivel in a detachable manner; this is done in order that the wristplate may be released from partaking in the motion of the rod, to enable the valves to be actuated by hand, which is sometimes done when starting and when stopping the engine, the wristplate being provided with an eye—clearly shown in Figs. 1 and 2—to receive the end of a hand bar.

By an inspection of Figs. 1, 2, and 3 it will be seen that the intervening mechanism between the wristplate and an exhaust valve consists of the link, or rod, *r′* (the *exhaust*

valve rod), the crank *b* (the *exhaust crank*), and the spindle, or stem, *s'* (the *exhaust valve stem*), which latter is provided with a T-shaped head that fits into a slot in the end of the valve, and thereby imparts to it its own motion, directly and in an unmodified manner. It will be noticed that the crank *b* is keyed to the stem *s'*; there is, thus, at all times a positive relation between any position of the wristplate and the simultaneous positions of the two exhaust valves.

The pedestal, or bonnet *B'*, that supports this mechanism also contains a stuffingbox that prevents steam from leaking by the valve stem, and also forms the bearing for a collar on the stem that takes the end thrust exerted on this by the steam pressure; all of which is clearly shown in Fig. 3.

Turning now to the mechanism by which the wristplate actuates an admission valve, it will be seen that, by means of the rod *r* (the *admission valve rod*), it primarily imparts its motion to the bell-crank *b* (the *admission crank*) that oscillates on the journal-shaped end of the pedestal, or bonnet *B*, that forms the support for the mechanism. Keyed to the end of the valve stem *s* there is a second bell-crank *d* (the *dashpot crank*), and it is by a periodic automatic coupling together and releasing of these two bell-cranks that the wristplate actuates the valve in the desired manner. Attached to the inner arm of the dashpot crank *d* is one end of the link or rod *t* (the *dashpot rod*), whose other end extends down to the closing apparatus *P*. This apparatus, commonly referred to as the *dashpot*, and which is described more fully further on, is a device that always tends to resist any upward motion of the rod *t*, and to promptly pull it down again into its lowest position when the dashpot crank is released from the admission crank and thereby left to the influence of the closing device alone.

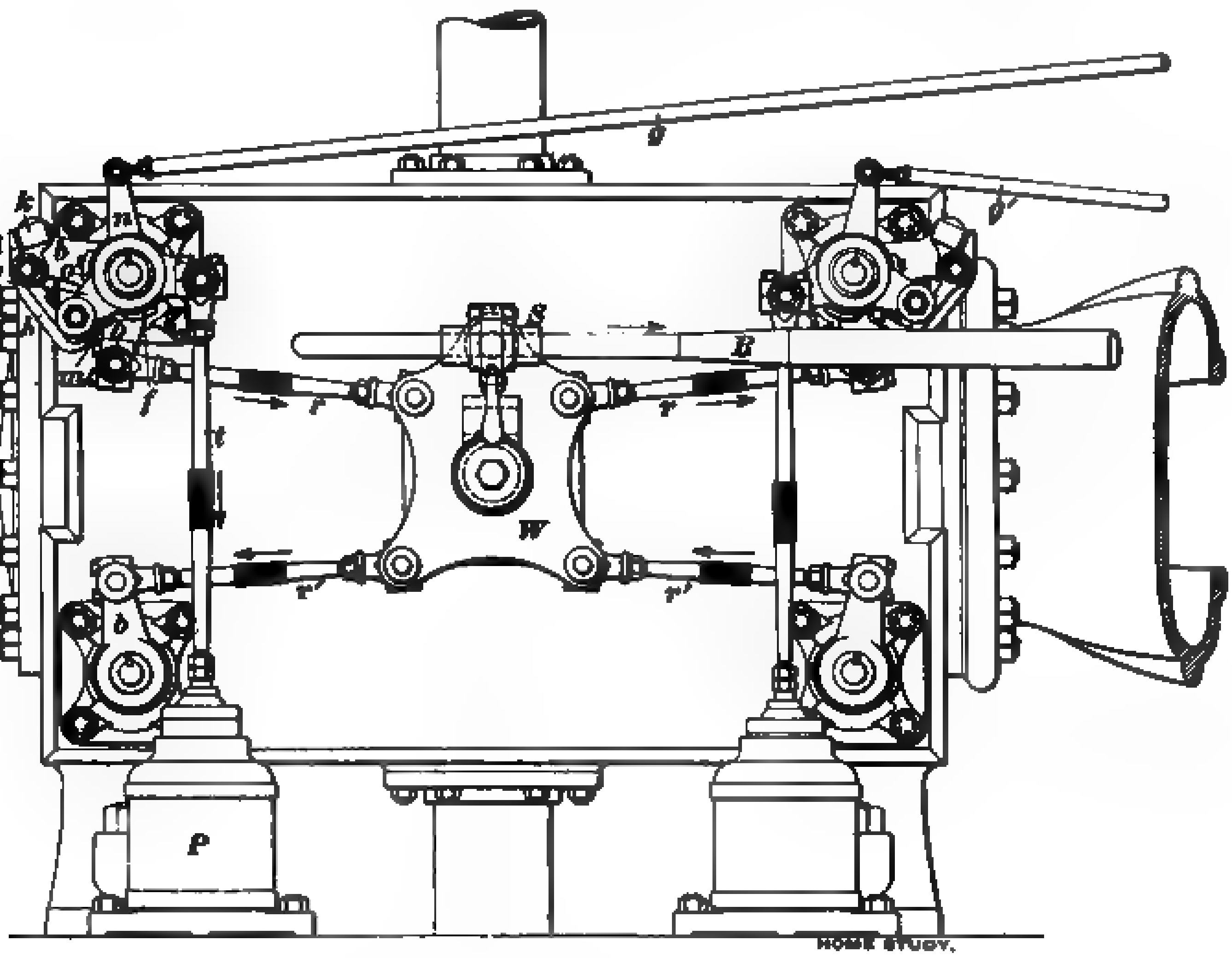


FIG. 2.

The coupling member between the two cranks is the hook-shaped piece *h* (the *valve hook*), which it will be noticed is fulcrumed to the outer arm of the admission crank *b*. Fastened to this same arm of the crank is also a little box *k* that contains a helical spring and a plunger. This is seen to be so arranged that the spring tends to force the plunger out of the box, the action of the plunger thereby exerting a pressure against the projection, or *toe*, *i* of the valve hook. On account of this pressure against its toe, the lower end of the hook always tends towards the center of the mechanism, and

accordingly requires something to stop against in order to remain in any particular position relative to the crank to which it is fulcrumed. When the two cranks are disconnected, and their angular positions relative to each other differ most from their *hooked-up* positions, then the little roller *m*, which is mounted on the projecting end of a pin inserted sideways in the extreme end of the hook, rests against, and rolls along, the outside of the collar *c* (the *governor collar*) that is mounted and free to turn on the outer end of the hub of the admission crank, and thus determines the innermost position of the hook. (See Fig. 2, *A*.) As will be seen, the governor collar is provided with an arm *n* to which is attached the end of one of two long rods *g* and *g'* (the *governor rods*), both of which rods extend forward to the governor of the engine, one end of each being attached to an end of a double lever that is mounted on a small rock shaft on the governor, and controlled by this.

In the hooked-up condition of the mechanism—which is that of the head-end mechanism, as shown in Fig. 2—the square head *p* of a tightly driven bolt (the *hook bolt*) in the outer arm of the dashpot crank *b* forms a stop for the hook, which not only prevents the hook from further turning about its fulcrum on the admission crank, but—as will be readily seen—also enables it to act as a strut between the two cranks, and as such to impart the motion of the admission crank to the dashpot crank, and through this to the valve stem and the valve itself.

The release of the hook at the proper time is effected by the little segmental piece *f* (the *cut-off trip*) that is secured to the governor collar, and thus has its angular position relative to the motion of the hook determined by the governor of the engine. As the valve rod pulls the cranks around, the roller on the hook will sooner or later reach the trip and ride up on it, and being thus forced further away from the center of the mechanism the hook releases its grip on the head of the hook-bolt, the dashpot being thereby left free to pull the whole released part of the mechanism back into the closing position of the valve. The whole mechanism is so adjusted that the hook, at the end of the return stroke of the admission crank, will again *drop in* and interpose itself between the two cranks.

The crank-end valve mechanism in Fig. 2 shows the dashpot with the rest of the released mechanism in its *home* position, and the admission crank on the return stroke ready to again *pick* it up.

When the engine is working under a light load, the governor collar *c* is kept in such position by the governor that the cut-off trip releases the hook early in its motion, while for a heavier load the reverse is the case. As, however, the motion of the hook is an oscillating one, it can evidently not be released by the trip after having once started on its return stroke, and, therefore, if ever the load on the engine becomes so heavy that the governor moves the trip too far to be reached by the hook when on its forward motion, the hook will not be released, at all, and the admission valve will then be actuated as if positively connected to the admission crank, in the same manner as the exhaust valves.

Fig. 3.

This *limited range* of *cut-off* of the *simple* Corliss valve gear constitutes one of its defects, which, however, is of no consequence for an engine that is never *overloaded*. The dashpot is shown in section in Fig. 1. It consists chiefly of three pieces: (1) The piece *x* which is secured to the foundation of the engines, and which is essentially a short and

wide cylinder, closed at the bottom and open at the top, and from the bottom of which projects a longer and narrower concentric cylinder that is closed at the top and open at the bottom. (2) The working cylinder y, which fits over the projecting cylinder of x, and is closed at the top by a cover that forms the socket of a ball joint by

FIG. 4.

which the rod t is connected to it, and which at the bottom is provided with an exterior flange that acts as an annular piston in the short, wide cylinder of x. (3) The casing h, which is screwed to x, and whose principal function is to prevent the rest of the apparatus from becoming a receptacle for dust and dirt. When the apparatus is working, the cylinder y appears to be a plunger working in the casing h, and is usually referred to as the *plunger*.

As will be noticed, the top of x is provided with a little valve v that opens downward; this valve is held to its seat by a light helical spring, while its bottom is provided with a small passage way leading into the large air space formed by the casing h.

The action of the apparatus is as follows: When the plunger y is being lifted by the rod t, the two chambers N and M become greater and greater, the small initial amount of air in N—which has no communication with the external air—becoming, in consequence, more and more rarefied, and the air in M becoming somewhat rarefied, as its only communication with the air in the casing is through the very small passageway in the bottom of x. However, if the release of the dashpot crank does not occur very early, the partial vacuum thus formed in this chamber M is gradually reduced by air leaking into it through a number of little holes in the upper part of its outside wall, and, finally, entirely destroyed if the piston of the plunger lifts completely out of it.

On account of the almost perfect vacuum thus created in the chamber N, and the partial vacuum created in the chamber M for short lifts of the plunger, the atmospheric pressure exerts upon this a powerful downward pressure, which on the release of the valve mechanism sends it back to its bottom position with great promptness, so much so, in fact, that it would strike home a very objectionable blow if it were not for the cushioning effect of the air that accumulates under its piston in the chamber M, which air has to be driven out again through the narrow passageway in the bottom of x.

It is in order to get sufficient cushioning effect that it is necessary to completely destroy the vacuum in the chamber M when

the plunger rises very high, for then it acquires a great momentum on its downward flight. The valve v enables any small amount of air that may have leaked into the chamber N on the upward motion of the plunger to be again forced out on this settling down to its home position.

Being now familiar with the details of the valve gear, we will turn our attention to the diagrams A, B, C, D, and E of Fig. 5, which exhibit the most significant simultaneous positions of the piston and the four valves, together with a skeleton outline of the principal members of the mechanism in their various corresponding positions, during a little more than a complete forward stroke of the engine.

In all the diagrams the directions of motion of the piston, wristplate, and valve rods are indicated by arrows, a double-headed arrow being shown when a member is in the position in which its direction of motion is being reversed, and a dotted arrow being shown when an admission valve rod is moving without affecting its valve, on account of their connecting parts being in the released condition. Fig. 4 shows the piston nearing the end of its backward stroke, and all the valves closed. The wristplate is in its middle position; hence the exhaust valves are in precisely the same position, relatively, to their respective ports, as would also be the two admission valves, were it not that the one, a', is in the released condition.

Observing the arrows on the various valve rods, it will be seen that the exhaust valve e' will soon be opened to liberate the steam that is still exerting an expansive pressure in the direction of motion of the piston, while the other e has but lately been closed; the admission valve a will also soon be opened to admit steam against the motion of the piston.

In Fig. 5, A, the respective positions of the crank and eccentric that correspond to the positions in Fig. 4, are D and D', and the position C of the crank indicates when the closing of the exhaust valve e actually took place and the resulting compression commenced, as indicated at C'' on the diagram of Fig. 5, B, while the position L indicates where the admission valve a will open—in other words, the lead position of the crank.

Fig. 5, C, shows the piston at the end of its backward stroke; or, what is the same thing, at the beginning of its forward stroke. By this time both the exhaust valve e' and the admission valve a have been opened considerably, without, however, having anything like reached the limits of their opening

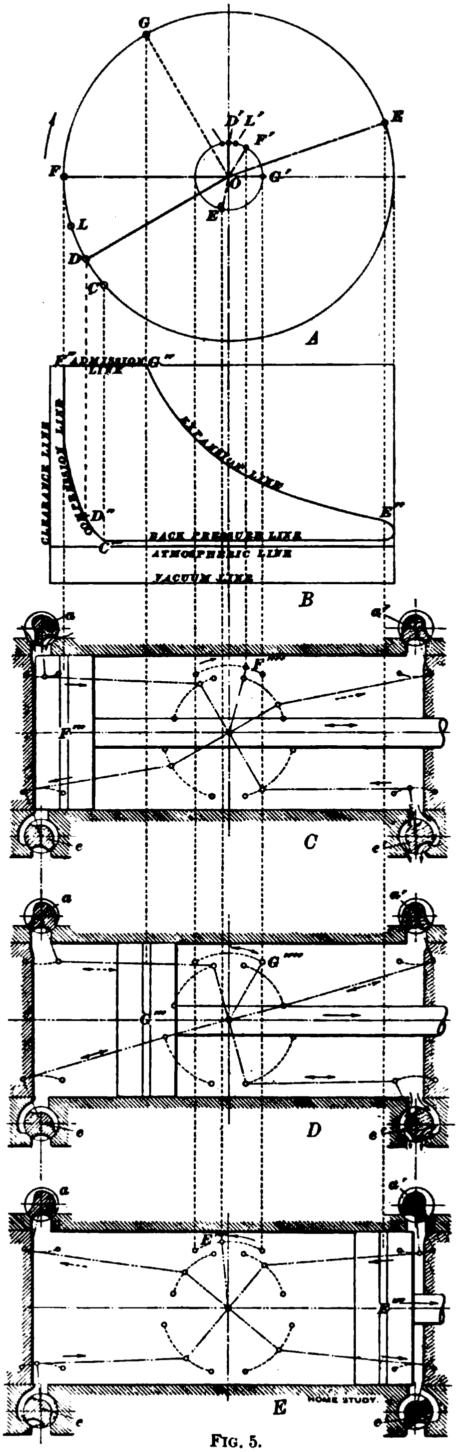


FIG. 5.

positions, while the exhaust valve e has nearly reached the limit of its closing position, and this because the four points of attachment of the valve rods to the wristplate are, as will be seen, so located that the angular closing movements of the valves are very small compared with their angular opening movements.

In Fig. 5, *D*, the wristplate is shown in the position in which its motion is just being reversed by the eccentric, the valve rods being, in consequence, also in the positions in which their motions are reversed, as indicated by the double-headed arrows. According to what we have already learned, this constitutes the limiting position for the releasing of the admission valve a, which for that reason is supposed to have just occurred, as indicated by its closed position. As indicated at G'' on Fig. 5, *B*, this is then the moment at which, in this particular case, the expansive reduction of the driving pressure on the piston commences. The exhaust valve e has at the same time reached the actual limit of its closing position, while e' has reached the limit of its opening position. In this position of its valve rod the admission valve a' is picked up, as indicated by one-half of the arrow being represented in full.

G and G' in Fig. 5, *A*, are, respectively, the positions of the crank and the eccentric that correspond to Fig. 5, *D*.

In Fig. 5, *E*, the piston is finally represented in that position, near the end of its forward stroke, for which the exhaust valve e just begins to open for the liberation of the expanded steam, e' having been closed some time previously to produce compression, and the admission valve a' also nearing its opening point for the lead position of the piston, which will be reached presently.

The point E'' on the diagram of Fig. 5, *B*, shows the release of the expanded steam due to the opening of e, and the points E and E' in Fig. 5, *A*, represent, respectively, the positions of the crank and the eccentric corresponding to Fig. 5, *E*.

HIGH RAILROAD SPEEDS.*

H. Rolfe.

SINGLE DRIVERS FOR FAST WORK—EFFECT OF ROTATIVE SPEED ON M. E. P.—FREE EXHAUST. VIRTUE OF AMPLE BOILER POWER—MAXIMUM ROTATIVE FORCE.

THE LOCOMOTIVE.—The most important of all the factors in the attainment of high speeds is, of course, the locomotive itself, as to the power and design of which something will now be said.

A locomotive should be designed for the work in hand, and should not be made too heavy, or powerful, for the average train that it will have to haul. A mistake too often made is that of using very large, heavy engines where they are not required. Such engines not only tear up the track and "eat their heads off" in the matter of fuel, but possess an undue surplus of power after reaching full speed. True, they get away quickly, but rapid starting is of minor importance on long "through" runs. For such traffic, it is best to use engines designed for their intended loads at the *maximum desired speeds*, and putting up with the somewhat reduced starting speeds, as being a matter of but slight importance.

If exceptionally bad weather, heavy sections of road, and extra cars are ever encountered in combination, put on a pilot, or helper. Most of the fastest express trains in Great Britain are now run by *single* engines. These handle trains weighing from 200 to 250 tons comfortably enough, at booked speeds of 54 miles per hour. If for any cause it becomes necessary to make use of a pilot, a "wire" is sent ahead for one, and schedule time is thereby kept. These engines burn from 25 to 28 pounds of coal per train mile—a consumption smaller than in United States practice. Their coal is better than ours, but their trains run harder, while, on the other hand, our trains are, as a rule, heavier than theirs. If the roads are tolerably level and the loads not too heavy, driving wheels of large diameter can be used with advantage, and *are* coming into more general use. On this side of the Atlantic small wheels have always been preferred,

* *Continued from September, 1898, Number.*

while in England large ones have been the favorites, 6 feet 6 inches being there regarded as the *minimum* diameter for express work. Some years ago the superintendent on one of the English roads brought out some 4-coupled engines with about 62-inch drivers. He said they were "the express engines of the future." As a matter of fact, they were soon put on a branch line, and there they are to this day.

Where the roads are good and can stand the concentrated weight, use a single pair of drivers. Of course, the weight on single drivers has to be very great; in England, an average for the most powerful express engines is about 42,500 pounds. The only *single* express engine that we know of in this country has a driving-wheel load of 48,000 pounds. This is a Vauclain compound, which was built at the Baldwin Locomotive Works in 1895 for running the Royal Blue trains of the Philadelphia and Reading Railroad. The writer had the pleasure of a trip on the foot-board soon after this engine came out, and was highly pleased with it, and would be glad to see more of the same type put in an appearance.

Single engines are best adapted for through runs and comparatively light loads, but other good work has been done with them—especially since steel rails and the sand blast came into use. Steel rails make it possible to employ greater wheel loads, while the sand blast, by increasing the friction between the rails and the wheels, leaves the designer free to use greater cylinder power.

As already explained, "single" engines lose a little time in starting, but they make up for it afterward by extra freedom in running. They can, as a rule, run down a given hill faster than a coupled engine. It is true that, in the latter type, the side rods, hubs, and pins, can be perfectly balanced, but, where these parts are absent, greater freedom of running results. The oil and repair bills are lighter, too.

In England, where "singles" are in common use, express trains are comparatively light, and are run at short intervals; in this country similar trains are much heavier, and are run less frequently, for which reasons—especially as the tendency is to make our trains still heavier—"single" engines need not be looked for here. On many American roads, even the four-coupled engines—the "American" type—are now regarded as inadequate, with the result that the "ten-wheeler" is becoming more and more the standard.

By using large wheels, the rotative speed is less for a given train speed, and this is a very important matter in connection with the question of high speeds. As regards economy, it has been proved by experiment that for every engine there is a certain rotative speed which gives the best results. Professor Goss, who made the experiments referred to, found that the best results were obtained when the particular engine under test was making 200 revolutions per minute, the piston speed being then 800 feet per minute. At this point the steam consumption per horsepower per hour was lower than at any higher speed. It was also found that below this particular speed (designated by him the "critical" speed of the engine) the coal consumption per horsepower per hour was practically constant. Now, the larger the wheel, the lower the piston speed for a given train speed; hence, the advisability of large wheels where the roads and loads render them suitable. There is another way in which the diameter of the driving wheels affects the speed of the engine. As the number of revolutions per minute of the wheels *increases*, the duration of port opening and exhaust *decreases*; the steam has then less time during which to supply the necessary power for maintaining the speed, the gradual opening, in the case of an eccentric-driven valve, having the effect of still further reducing the quantity of steam passing through the ports. Take two engines, A and B, with 90-inch and 66-inch drivers, respectively. Suppose both to be running at 70 miles per hour. They will be making, in round numbers, 260 and 355 revolutions per minute, respectively, neglecting slip. Now, the valve gear, etc., may be identically the same in both engines, which may also be running with the same cut-off; yet, more steam will get into A's cylinders than into B's, because the duration of port opening is 36½ per cent. greater. Thus, the mean effective pressure on A's pistons will be greater than on B's. The actual variation in M. E. P., with given boiler pressure and cut-off, depends not only on the speed of revolution—the point now under consideration—but also on the length of the steam ports and the type of valve—that is, whether the Allen or the ordinary slide.

The exhaust opening will also extend over an interval of time correspondingly greater in A's case, so that the steam can get away more freely, thus resulting in less back pressure and still further increasing the effective pressure on the pistons. In B's case this extra back pressure causes extra

friction at the crankpins, and thus absorbs some of the power developed.

The question of free exhaust is a vital one. The writer has seen something of the evils of a cramped exhaust. There were, at one time, on a certain English road, some engines that gave trouble in this respect. They worked economically enough, using only about 24 pounds of coal per mile, but they wouldn't *run* freely. The superintendent tried the effect of giving them more regulator area, and after that, more steam pipe area, but the fault lay elsewhere. Plenty of steam got *into* the cylinder. The trouble was in getting it *out*. These engines had ⅛ inch inside lap—a preposterous thing. But the superintendent believed in plenty of compression—carrying it up to the initial pressure, in fact. While resulting in fuel economy, it at the same time seriously affected the running of the engines, the very highest speed the writer ever knew one of them to make being 65 miles per hour, and that was down a 20-foot grade. The cause of the trouble lay not only in a *late* but also in a *cramped* exhaust. The cylinders were 18½″ × 26″; the exhaust port was only 15″ × 2″, being thus but 11½ per cent. of the piston area, instead of from 18 to 20 per cent., as adopted in the best practice. Still, the above superintendent had a certain amount of "method in his madness," for it doubtless seemed to him an anomaly to make the area of the exhaust port more than 30 square inches when that of the steam port (through which all the exhaust steam has to pass anyway) was only 15″ × 1⅜″, or just over 20 square inches. These engines used to "choke" or, as the drivers expressed it, work against themselves.

Without doubt, much of the fast running in this country is largely due to the free exhaust the engines have. When the steam has done its work it cannot be got rid of too quickly. Therefore, when high speeds are aimed at, the exhaust passages must be of ample size and as direct and smooth as possible. The same remark applies to the blast pipe. It seems at first sight rather contradictory to provide large exhaust ports and then to "stop the way" in the blast pipe. Yet this has to be done in locomotives, in order to provide sufficient draft for the fire. In Europe, the "variable blast" has been in use for some time, the nozzle of which can be widened or contracted at will, according to the nature of the road and the requirements of the fire. In connection with the port question, it may be mentioned that some engines have been lately built, having separate steam and exhaust ports—undoubtedly the right thing in principle. It has yet to be proved, however, whether the plan is of any advantage in practice.

To recur once more to single engines: The larger the driving wheel used, the less the tractive power; this can be met, however, by increasing the stroke. The largest driving wheels now in use in England on regular express trains are the "8-footers" on the Great Northern, the tires of which are 97½ inches in diameter when new. These engines have a 28-inch stroke. At a given train speed, they have the same piston speed as an engine with 83½-inch drivers and 24-inch stroke, but their rotative speed is only 85½ per cent. as great, while the duration of steam and exhaust openings is 16⅔ per cent. greater. There must be some advantage in this.

As the speed of the train depends on the power of the engine, we must evidently have the cylinders large enough, and the steam pressure sufficiently high. A disadvantage attaches to long strokes, in that the cylinder condensation is greater with a given percentage of cut-off. But, if the object in view is simply to increase the speed, the slightly increased consumption of fuel and water must be regarded as a secondary consideration.

The cylinders must be designed in proportion to the weight on the drivers. Large diameters and high pressures call for heavy loads on the rail. An engine that is "over-cylindered" will give trouble through slipping, thereby losing speed and wasting steam.

The capacity of an engine, however, is always ultimately referable to the boiler power. It is evidently of little use to have large cylinders if, during a large part of a run, there isn't enough steam to keep them well supplied. The higher the speed, the greater the number of revolutions in a given time, and the greater number of times per minute, therefore, has the cylinder to be supplied with steam; hence, the greater the demand on the boiler. If the engineer wishes to do something out of the ordinary, it will not help him any to start away with steam enough escaping from the pops to lift the station roof off, and then, after the first half mile, running the remainder of the journey with only, say, 130 pounds instead of 160 pounds of steam pressure; such a practice is pretty common on the other side, with their small-boilered engines. This is the weak point in many of the English engines: they haven't

the steam resources that ours have; drivers seem to be satisfied if the gauge needle is within from 10 to 20 pounds of the blow-off pressure. Then, when called upon for a spurt—to make up lost time, say—they find they cannot do it, for want of steam. This lost time that an engineer is often called upon to make up (but which he generally *doesn't*) is often due to slipping, especially in the case of single engines in bad weather or when meeting an up-grade tunnel. On this point of slip something further may here be said. The rotative force depends on two things: piston pressure and position of cranks. When *one* of the cranks is in the most favorable position for turning the wheels—that is, when the tangential component of main-rod thrust is greatest—the *other* is in a very unfavorable position. Then, again, the maximum pressure may or may not correspond with the most favorable position of the cranks; this matter depends on the cut-off. It is clear that, if the rotative force at the crank varies greatly, there will be a tendency to slip. Taking the case of a main rod 9½ feet long and a 2-foot stroke, it will be found that for a cut-off pressure of 100 pounds the ratio of the maximum to the average rotative force varies from 1.52 at ⅛ cut-off to 1.09 at ½ cut-off; for 200 pounds, the respective ratios are 1.47 and 1.09; so that the variation is greatest with the earliest cut-offs. These, however, accompany the highest speeds, and so the inertia of the wheels (acting as ordinary flywheels do) tends to some extent to prevent slipping.

As regards the matter of British lack of punctuality, owing to the engineman adhering most scrupulously to his running time, Mr. Acworth described the situation in one very pregnant sentence in a letter to the London "Times" not long ago, wherein he pictured a train leaving the terminus 3 minutes late on a 200-mile run, and coming in at the end faithfully *3 minutes late*, although there's not the shadow of a doubt that out of a 4 hours' run the engine could have squeezed a paltry 3 minutes. The writer can, in the main, indorse Mr. Acworth's remarks, absolutely.

(To be Concluded.)

THE DUPLICATION OF DRAWINGS.

Louis Allen Osborne.

Old Methods—Introduction of the Blueprint Process—Improvements on Blueprinting—Transfer Process.

HALF a century ago, the engineer and architect were entirely dependent upon tracing paper and draftsmen's skill for the production of duplicate copies of working drawings. The necessary tracing and retracing of every plan, until the required number of copies was obtained, made the expense very great, and it is no wonder that the introduction of a process by which drawings could be duplicated at one-tenth the expense of tracing was enthusiastically received.

It was in 1843 that Sir John Herschel, while experimenting in photography, investigated the effect of light on various iron compounds, and afterwards perfected a method of photo-printing which he called the *cyanotype*.

The cyanotype was nothing more than a primitive form of the blueprint process. The lack of facilities for obtaining pure chemicals made the preparation of the paper somewhat difficult in those days, but the resulting material was precisely the same as the commercial blueprint paper of today.

The application of the cyanotype to the reproduction of working drawings revolutionized drafting-room practice. The danger of error due to oversight in tracing was reduced to a minimum, and the great labor of carefully checking a large number of duplicate tracings was obviated entirely. A carefully plotted drawing, and an accurately traced copy, were all that was required of the draftsman, while an unlimited number of duplicates could be turned out by the blueprinter, each copy being precisely like the original tracing, so far as the relations of lines and dimensions were concerned.

But it is contrary to human nature to be content with but a single improvement. It is a strange but well demonstrated fact that man will plod along, contented with the most primitive ways and methods, for an indefinite period; but just as soon as some one shows him an improvement on his methods, he eagerly accepts the improvement, and demands, at the same time, something still better.

It was the same with blueprinting. Architects and engineers were delighted with the process, for they found that it not only saved them much labor, but trebled the output of their drafting rooms. Soon, however, they demanded something more. The blueprint was a negative copy of the drawing ; that is, the lines were white on a colored ground, while in the original tracing the lines were black on a white ground. Experimenting continued, and a process was presented which gave a copy in blue lines on a white ground. This, however, was not entirely satisfactory, and when, finally, several processes were invented, each of which gave a reproduction of the original, in black lines on a white ground, the impatient practitioner complained of the trouble and expense involved.

Everything has been done to perfect these photo-printing processes, and at the present day there is little room for improvement. The one disadvantage of all of them lies in the fact that sunshine is necessary for the printing, and unless the day is bright, little or no printing can be done. For this reason several attempts have been made to devise a mechanical method of reproducing drawings, which shall be independent of weather conditions, and at the same time simple and inexpensive in operation. So far, these attempts have been only partially successful, though, for some purposes, fairly good results may be obtained.

The simplest of all of the photo-printing processes is the cyanotype, or blueprint, the paper for which may be prepared as follows : In a dark-colored or opaque bottle dissolve 2 ounces of citrate of iron and ammonia in 8 ounces of water, and in a similar bottle dissolve $1\frac{1}{4}$ ounces of ferricyanide of potash in 8 ounces of water. Immediately before use, mix equal portions of these solutions, and, by means of a soft sponge, a wad of cotton, or a camel's-hair brush, spread the mixed solutions evenly over the entire surface of a heavily sized white paper. This must be done in a room lighted with gas or other artifical light whose color tends toward yellow, and the paper should be dried quickly in a dark room or closet. The tracing is laid on a sheet of heavy glass (or preferably in a printing frame) with the drawing next the glass ; the prepared paper is then laid over the tracing with its prepared side against the tracing cloth. A piece of heavy blotting paper, or felt, is then laid on the back of the paper, to distribute the pressure and keep the tracing and printing paper in close contact ; a board is then placed over the felt, and the whole is submitted, glass side up, to the rays of direct sunlight. In from three to ten minutes the print is removed and washed in clean water, when the entire surface becomes a deep-blue color, except at the points protected by the lines of the tracing, where the paper will remain white.

After washing, the print is hung up and allowed to dry, when it is ready for use as a working drawing. Any desired alterations in the print may be made with an ordinary writing pen and a solution of caustic soda. This solution, applied to the blue portions of the print, will immediately bleach it white, while any existing lines may be obliterated by means of a little Prussian-blue water color, or even an ordinary blue pencil.

The printing frame for use in the making of sun prints consist of a rectangular frame, or box, as shown in Fig. 1, on one side of

FIG. 1.

which is fixed a pane of clear plate glass *a*. The tracing is then laid in the frame against the glass, as shown at *b*, and the printing paper next, as shown at *c*. A felt pad *d* is then spread over the back of the paper, and the wooden backing *e* is put in, to hold the paper and tracing against the glass. The arms *f* are then turned down, and the springs *g*, pressing against the cleat *h*, keep everything tight in place, while the catches *k* hold the arms down. The frame is then turned over, and so placed that the sun may shine through the glass and tracing on to the printing paper.

The backing is usually made in two or more pieces, as shown, in order that the frame may be partially opened and the progress of the printing examined, while one of the arms is still clamped down and

secures the end of the tracing and paper from slipping. If the print is then found to be insufficiently printed, the back may be replaced and the exposure continued.

When the printing frames are large, and not easily handled, it is customary to build a track out through a window, as shown in Fig. 2. The frame is then provided on each side with a flangewheel *a* for running on the track *b*. When the frame is taken in to remove the print, or to put in a new tracing, it is simply turned over on the wheels, as shown by the dotted lines. The back is removed, the tracing and paper adjusted, and the back replaced. The frame is then turned glass side up, pushed out on the track, and left in the sun till the printing is completed.

Next in simplicity to the ordinary blue-print process is the blue-line process, whereby the reproduction shows in clear blue lines on a perfectly white ground.

The paper is coated with the following solution:

Gum arabic	385	grains.
Perchloride of iron	123	grains.
Tartaric acid	62	grains.
Sodium chloride	46	grains.
Water	3½	ounces.

When dry, the paper is exposed under a tracing, as in the previously described process, and, when sufficiently printed, is immersed in a saturated solution of ferrocyanide of potassium until the lines are fully developed. It is then rinsed in a dilute solution of hydrochloric acid, to remove any yellow stains due to the ferrocyanide, and is finally washed in water.

Alterations in the finished print may be made with an ordinary pen and a rather thickly ground solution of Prussian-blue water color. Existing lines may be removed with the soda solution previously described.

The processes for printing black lines on a white ground are numerous, but somewhat complicated. One of the earliest forms consisted of a process of double printing, and, though more complex and expensive than later methods, it gives results that leave nothing to be desired.

A sheet of thin but close-grained paper is immersed for half a minute in a solution of common table salt and then dried; it is then brushed over with a solution of 10 grains of nitrate of silver in 1 ounce of water, and again dried. The paper is then exposed under the tracing and printed until the lines just commence to change color, while the ground becomes a deep-bronze color. The print is then soaked for ten minutes in a solution of 1 ounce of hyposulphite of soda in 10 ounces of water, and afterwards well washed in water and dried. When dry, the print is rubbed over with sweet oil, to render it transparent, and is then put in the printing frame in the place formerly occupied by the tracing. A new print is now made under the oiled copy, and this second print is soaked in the soda solution and washed in water, the same as the first one. The result is a clear white ground, on which the lines of the drawing are duplicated in a deep-bronze black, equal in every respect to an inked drawing. Any number of prints can be made through the oiled copy, but the process is so troublesome, and takes so much time, that it never found much favor except for special work and small sizes of drawings.

A paper for direct printing of black lines on a white ground may be prepared as follows: In 9 ounces of water dissolve

Gelatin	3 drams.
Perchloride of iron solution	6 drams.
Tartaric acid	3 drams.
Ferric sulphate of iron	3 drams.

Apply two coats of this solution to the surface of a heavily sized paper, allowing each coat to dry thoroughly. Print as usual, under a tracing having somewhat heavy and well defined lines, and develop the print in a solution consisting of 6 drams of gallic acid dissolved in 32 ounces of water and 6½ ounces of alcohol. The lines will appear strong and of a deep purple-black color, and the ground will assume a cream tint, afterwards changing to a pale gray. The print should then be washed in several changes of water and hung up to dry. Additional lines on this form of print can be made with ordinary drawing ink; existing lines can be removed only by careful rubbing with an ink eraser.

The quality of any print produced by the agency of sunlight is dependent very largely upon the tracing from which it is made. The lines of the original should be strong and of an even density, and the ink used should be absolutely opaque.

The best results are obtained when the ink with which the tracing is made is mixed with a small quantity of thickly ground chrome-yellow water color. If the color refuses to mix freely with the ink medium, a drop of ox-gall will clear it and cause it to flow more freely—though too much gall will give it a tendency to blot.

Regardless of the numerous disadvantages, nearly all mechanical drawings of the present day are reproduced by some one or other of

the sun-printing processes. There is, however, an increasing tendency among users—architects particularly—to adopt the more recent method of printing by means of mechanical transfer. This consists of making duplicate copies of an inked drawing or tracing by placing it in contact with some prepared surface that will absorb a portion of the inked lines, and afterward transfer them to other sheets.

The disadvantage lies in the fact that the ink necessary for the purpose must be colored with an anilin dye, thus becoming very difficult to handle and dirty to use. It has a corresponding advantage, however, inasmuch as different parts of a drawing can be made with different colored inks, and the copy will show these color relations.

The materials necessary for the transfer process may be prepared as follows: Soak 4 ounces of white glue in 5 ounces of water and 3 ounces of strong aqua ammonia. When the glue is soft, warm the solution, by setting the vessel containing it in a pan or pail containing boiling water. When the glue is dissolved, add 3 ounces of granulated sugar and 8 ounces of gelatin; then let it come to the boiling point until the whole becomes liquid. While still hot, paint the solution on sheets of heavy white blotting paper until the latter is thoroughly saturated; then lay them away to dry, for two or three days.

When ready for use, slightly moisten the surface of a sheet with a sponge dipped in cold water, and lay the drawing or tracing (which has been executed with the prepared inks already described) over the pad so that every part of the inked lines comes in contact with the sheet. Rub the drawing on the back into close contact with the prepared blotter, and after two or three minutes carefully remove it. Sheets of plain white paper laid over the pad and gently rubbed into contact will receive a complete impression nearly as clear as the original; from six to ten copies may be thus obtained from a single impression. After use, the pad should be laid aside for 24 hours, after which the ink will be found to have sunk into the blotter and a new drawing may be transferred. The pads should be kept in a horizontal position on a shelf or in a drawer, away from heat and dust.

Fig. 2.

The inks required for these pads may be mixed as follows:

Black Ink.

Anilin black	1 ounce,
Water	14 ounces,
Glycerin	4 ounces.

Blue Ink.

Anilin blue	1 ounce,
Hot water	7 ounces.

Add, when cool,

Spirits of wine	1 ounce,
Glycerin	½ ounce,
Ether	10 minims,
Carbolic acid	1 minim.

Red, violet, or green ink may be prepared by substituting the desired color of anilin for the one mentioned above.

FIREPLACES.

W. M. Brown.

OPEN FIREPLACES VERSUS CLOSED STOVES—HOW TO DESIGN A FIREPLACE—HEIGHT AND SHAPE OF OPENING—CORRECT PROPORTIONS—DRAFT—CURE FOR SMOKY CHIMNEYS.

ABOUT the time when inventors had brought the heating stove to the point where it was reasonably economical, a hue and cry was raised against the open fireplace, and it became fashionable to charge it with all the villainies in the catalogue. "Wasteful," "Smoky," "A promoter of drafts," "Roast your face and freeze your back," "Dirty, ugly hole in the wall," and many other uncivil things were said of it; yet, when all that was urged against it is thoroughly sifted, it really has its foundation in the one prime charge of wastefulness of fuel. As the fireplace has been usually constructed, it cannot very well be denied that this prime charge was well founded. The fault should, however, have been laid to the constructor and designer—where it belongs—and not to the fireplace itself.

That the fireplace possesses advantages that never have been and never can be denied, even by its most urgent enemy, is evidenced by the hundreds of cast-iron and sheet-iron half-fireplace and half-stove affairs that are constantly finding their way into the market and from there into our houses. Say what we will, an open fire possesses a charm and an invitation to sociability that no other form of house heater can boast of. What, for instance, is more dreary and cheerless than a steam radiator, however designed and ornamented? Every year the fact is making itself more and more felt that the modern dwelling house without a fireplace is incomplete, and the architect nowadays finds himself constantly required to provide one or more of them in nearly all those dwellings built and designed for a home for the builder. We shall attempt in this article to point out the best construction for a fireplace of moderate cost, leaving the wealthy to expend as much money on fancy, bizarre, and patented high-priced affairs as they may choose.

In Fig. 1 we show the plan or configuration of a properly designed fireplace built into a chimney. Here *a* denotes the width of the opening in front; *b*, the width of the rear or back; and *c*, the side walls, standing at angles with the front and back lines. It is of vital importance that these angles be properly laid out, and as a guide a rule may be stated as follows: The width *a* of the opening in front should be three times the width *b* of the rear wall; and the depth *f*, from the line of the front opening to the rear wall, should be just equal to the width of the back wall. However large or however small the fireplace may be made, yet, when it is constructed according to this rule, the side walls will stand at an angle of exactly 135 degrees with the line of the front opening and with the rear wall. The reason for having this special angle is that the effective heat from a fireplace is obtained mainly by radiation; and that, when the side walls stand at this angle, the rays of radiated

FIG. 1.

heat darting from the side walls cross each other in the fireplace, and are shot, without meeting any obstruction, across the room, diverging like an open fan, the largest possible area of the room being directly heated thereby. There can be no excuse for departing from this manner of construction, if the fireplace is laid out while the dwelling is being built; for, in that case, nothing stands in the way of so constructing it. In placing a fireplace in an old chimney it may become necessary to depart from this rule, in which case as little variation as possible should be tolerated. Having thus got our groundwork laid out, we show in Fig. 2 a front view of the fireplace, wherein the height of the front opening should never exceed 30 inches, no matter how large or how small the fireplace may be.

The reason for this is that in a fireplace a fire burns precisely as it would in an open field. To burn the wood or coal, that is, to have it blaze and consume, does not require a chimney flue. If the chimney flue were closed absolutely tight, the fire would burn practically as well as with the flue open; but, with the flue closed, the smoke would, of course, be projected into the room. The so called draft of the chimney, therefore, has nothing to do with the *burning* of the fire in an open fireplace, the only purpose of the flue being to carry off the smoke. We have reference here to the genuine open fireplace as shown in Fig. 2. In many so called open fireplaces in which the grate is fitted with various shutters and the main opening with a draw-plate, for compelling all the air that goes up the chimney to pass through the fire, there is no doubt that any attempt to make a fire burn would prove a failure if the chimney draft were faulty. Space does not admit of giving the scientific principles governing the 30-inch height of the opening, as it would require more than we can use in setting it forth. We therefore content ourselves with the simple statement of the fact. In some fireplaces which the writer has constructed, the height has not exceeded 27 inches. The point is not to *exceed* 30 inches; the height may be less if desired.

Having arranged for the width, depth, angle of the side walls, and height of the fireplace, we shall next consider the material of which to construct it. This should invariably be brick—firebrick if it is not too expensive—but, in any event, good sound brick, and, under no consideration whatever, metal of any kind. The reason for this is that brick is a poor absorber of heat, and the heat rays, instead of being absorbed as they would be by metal, are radiated from the brick into the room where they are wanted. If the slight additional expense does not stand in the way, perfectly smooth glazed bricks—those having a glassy surface—should be used, for they are still better. The reason for this is that bright surfaces absorb less heat than rough ones, so that the glazed bricks will reflect more of the heat into the room. Wherever such glazed bricks can be had, and they are quite common, their use is recommended.

The writer constructed a fireplace of glazed bricks, for burning wood, and found that, by using wood in such lengths and setting the andirons in such a manner that the blaze would play as little as possible on the bricks, and thus avoid smoking them, they stood the heat well, and the radiation from the glazed surfaces was distinctly felt to be greater by far than from a fireplace made of common brick. No *practical* harm results if the surface of the glazed bricks becomes smoked, as it can be wiped off with a damp rag when the fireplace is not in use, and the surface can thus be made clean and bright again. With coal as fuel, the basket should be small enough to set well away from the glazed brick, otherwise the heat may become so intense as to cause the glazing to run, and thus disfigure the surface.

FIG. 2.

In Fig. 3 is shown a vertical sectional view of the fireplace and throat of the chimney. The chimney throat is a matter of prime importance, since, if it is not properly constructed, a smoky chimney is invariably the result. It will be noticed that, in Fig. 3, the top of the rear wall of the fireplace lies near enough to the rear side of the front

wall of the chimney to choke the throat, leaving but a comparatively narrow egress for the smoke. The width of this throat, *e* in Fig. 3, should never exceed 4 inches, however large or small the fireplace is. The remainder of the chimney may be of the ordinary kind except that it should be plastered its whole length if the best results are desired. The common size of chimney flue will be sufficient for any fireplace that is not too large for the living rooms of an ordinary dwelling house. The reason for thus choking the throat of the chimney is that the heated air in the fireplace will cause the smoke to rise as high as the throat in any event; but at that point the draft of the chimney should be sharp and rapid, in the nature of a powerful suction, in order to quickly and powerfully *suck* the smoke into the chimney flue at this point. The writer has had experience with some chimneys that had been pronounced incurably smoky, in which, by arranging the throat as above described, the difficulty was fully and permanently cured.

FIG. 3.

To return to the height of the opening of the fireplace, it should be observed that all attempts at arching or otherwise beautifying the top of this opening should be omitted. Under no circumstances should there be any departure from a straight line when finishing the top of this opening. The reason for this is that, if the top is arched, the draft of the chimney flue will be most powerful (and almost entirely exerted) at the crown, or highest part, of the arch, and the smoke will curl out into the room at the sides, as indicated in Fig. 4. We have met with such arch-topped fireplaces that were unmitigated nuisances until a metal hood having a straight front line was adjusted, after which no trouble was experienced. In constructing the fireplace, there is no excuse for departing from the straight line. In Fig. 2 this line is indicated by *b b*.

When finishing the throat of the chimney, care should be taken to leave the surfaces smooth; this may be done by plastering them over. The smoother the throat is, the better will be the draft at this point.

Simple as all this seems, the fact remains that few masons know or seem to care to know the correct rules for building fireplaces, and all sorts of dimensions for the front opening, rear wall, side angles, and height of front opening will be used, and then surprise expressed that the fireplace does not work properly. A fireplace constructed on the rules herein laid down will always work well, provided the chimney flue is large enough to carry off the smoke. In case wood is desired for fuel, irons will be needed, which may be of any pattern desired; but, if coal is to be burned, a metal basket should be provided, preferably one having a dumping grate. With such a fireplace located in the common living room, and burning during evenings, a degree of comfort will be provided that cannot be obtained from stoves, hot air, water, or steam heaters. Nothing so conduces to comfort and pleasure as an open fire, when used in conjunction with other heaters, and the expense is trifling compared with the comfort and pleasure derived therefrom. The writer could suggest rules for making a combination fireplace and a hot-water heater of power sufficient to heat from two to four rooms or more, but the object of this article is simply to lay down the rules for the construction of an ordinary cheaply constructed fireplace, such as any one building an ordinary dwelling could afford to possess, and one that can be guaranteed to always work without filling the room with smoke. So simple a matter would hardly seem to require an article of this length, but our experience has been that, even in so simple a matter, failure is encountered more frequently than success. In most cases, the failures result from sacrificing plain principles of construction to attempts at fancy architectural effects and ornamental designs. An open fireplace can, of course, be made as ornamental as desired, provided the essential principles laid down herein are not departed from.

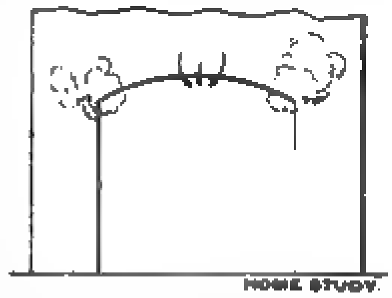


FIG. 4.

THE CIRCUMFERENCE OF A CIRCLE.

A. Langerfeld.

Graphic Methods for Finding the Length of the Circumference of a Circle—The Length of a Quadrant.

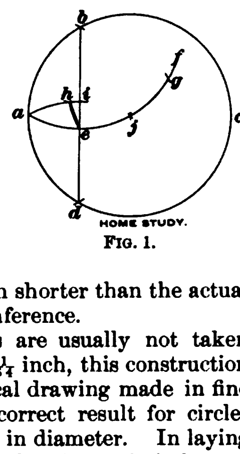
Any way of finding a length or size by means of a drawing is called a *graphic* method. There are many graphic methods by which close approximations to the length of the circumference of a circle may be found. Some of these are theoretically very accurate, but of little practical value because the constructions are of such a nature that average instruments and ordinary care in drawing with them do not suffice to get reliable results. The principal objections to many of these theoretically close approximations are that acute, and therefore uncertain, intersections are depended upon; that delicate measurements are repeated a number of times in succession, thereby magnifying even small inaccuracies; that straight lines, that are inconveniently long, are required; and that too many operations are involved. Any one of these objections makes a construction unreliable in its practical application.

In a mechanical drawing of ordinary dimensions, it is generally inconvenient to find, by a graphic method, the length of the circumference of a circle whose diameter is more than about 2 feet long; therefore, for circles as large as that, it is best to measure the diameter and calculate mathematically the length of the circumference. But in laying out work full size, as, for example, the sheet-metal worker has to do, it is often convenient to find a circumference by construction, even if the diameter is as much as 3 or 4 feet long.

The simplest approximation is, of course, to lay off three times the diameter and add one-seventh of the diameter. This will give the same result as the similar mathematical calculation of multiplying the diameter, in feet and inches, by $3\frac{1}{7}$, which is the rough approximation so well known and so convenient for general use. But it is rather troublesome to lay off one-seventh of a length, because there is no simple construction for finding it, and in a 4-foot circle a result so obtained will be about $\frac{1}{16}$ inch too long.

By the following construction the required addition to three times the diameter of a circle, to make the total length laid out almost exactly equal to the required circumference, is found. This construction has the advantages that it is all contained within the given circle, that only the radius of the circle is used for setting off distances and describing arcs, and that only one rather short straight line has to be drawn.

Let *a b c d*, Fig. 1, be the given circle, and *j* its center. Describe all the following arcs with a radius equal to that of the given circle. With center *a*, anywhere on the circumference, describe arcs intersecting the circumference in *b* and *d*. Draw *b d*. With *b* as center, describe an arc intersecting *b d* in *e*, and continue this arc, as shown, to *f*. With center *e*, describe an arc intersecting the arc *e f* in *g*. With center *d*, describe the arc *a i*. With center *g*, describe the arc *e h*, intersecting *a i* in *h*. The straight distance from *e* to *h* is the length to be added to three times the diameter *a c*, or to six times the radius *a j* to make up a length that is practically equal to the given circumference. In a circle 2 feet in diameter, the length so found is only about $\frac{1}{64}$ inch shorter than the actual length of the circumference.



HOME STUDY.
Fig. 1.

As measurements are usually not taken closer than within $\frac{1}{64}$ inch, this construction gives, in a mechanical drawing made in fine lines, a practically correct result for circles not exceeding 2 feet in diameter. In laying out work full size, drawings of circles are usually made in pencil lines at least $\frac{1}{64}$ inch thick, or by chalk lines $\frac{1}{32}$ inch to $\frac{1}{8}$ inch thick; so that a graphic result that is correct within about $\frac{1}{32}$ inch for circumferences of circles over 2 feet in diameter, is more nearly correct than would be a result obtained by a mathematical calculation based on measurements from such thick lines.

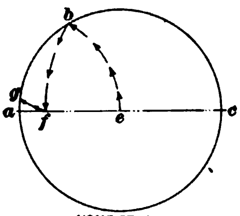
By the following method a result nearly as close as the foregoing is obtained for circles not over 1 foot in diameter. The advantages

of this construction are that the only line drawn is a diameter, and that all the rest of the construction consists in merely transferring distances, which may be done without describing any arcs, by using the dividers.

Let *a b c*, Fig. 2, be the given circle, and *e* its center. Draw the diameter *a c*. Make *a b* equal to the radius *a e*. Make *c f* equal to *c b*. Make *b g* equal to *b f*. Now, *f g* is the length to be added to three times the diameter *a c*. In a 12-inch circle this result is but a scant $\frac{1}{64}$ inch too long.

If only an approximation of the length of a circumference is wanted, it may be obtained by simply setting off the radius of the given circle twice on the circumference, as from *a* to *b* and *c*, Fig. 3, and then describing the two arcs *d* and *e*, with *c* and *b*, respectively, as centers, and with the same radius as the given circle. Three times the diameter, or six times the radius *a g* of the given circle, plus the widest distance between the two arcs *d* and *e*, will be nearly the length of the circumference. The shortage is almost exactly $\frac{1}{18}$ of the distance between *d* and *e*. This addition can easily be made by eye, by adding $\frac{1}{16}$ instead of $\frac{1}{18}$. One-sixteenth of *d e* is readily found by first dividing the distance between *d* and *e* in half, then one-half in half, which will give one-quarter; then one-quarter in half, which will give one-eighth; and then one-eighth in half to get the required sixteenth *d f* to be added as shown. As the distance between *d* and *e* is always rather small, the sixteenth *d f*, obtained by eye, will always be very nearly the correct addition required. Only experienced draftsmen and mechanics should use such approximate methods, however, because it takes a well trained eye to work that way. As, in sheet-metal work, there are certain allowances to be made for stretching, or for the thickness of the material, etc., these allowances can be made while adding the above sixteenth of *e d*. In some cases, as, for instance, in copper and brass work, and in silver ware which is to be planished, or hardened by hammering, the allowance to be made for stretching is often fully as much as the sixteenth of *e d*; so that the blank to be cut for a sheet-metal cylinder in such cases is right if cut equal to 6 times the radius plus *e d*, without any further addition. The sixteenth part of *e d* is equal to about $\frac{1}{352}$ of the circumference, or a scant $\frac{1}{32}$ inch per foot of diameter of circle. From this its relation to allowances of the above nature can be judged by experienced mechanics, and added or partly added, or entirely omitted, as the case may require.

The distance *e d* may also be found without describing any arcs, by proceeding in the same manner as in Fig. 2, and leaving out the last operation. The distance *a f*, Fig. 2, is the same as that between *e* and *d* of Fig. 3.



HOME STUDY.

FIG. 2.

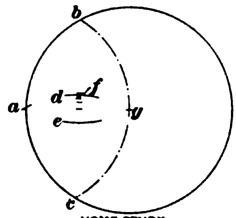


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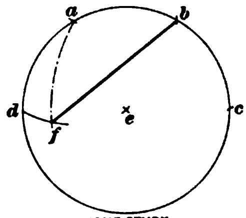
FIG. 3.



HOME STUDY.

FIG. 4.

It is often desirable to find one-half, or one-quarter of the length of a circumference —that is, the length of a quadrant. The latter is found very accurately by the following construction: Let *a b c d*, Fig. 4, be the given circle, and *e* its center. With any point *a* on the circumference as center, and with a radius equal to the radius *a e* of the given circle, describe the arcs *d f* and *b*, intersecting the circumference. Make *b c* equal to *b a*. (Or, *c* may be located by drawing a diameter from *d* through *e*.) Make *c f* equal to *c a*. The distance *b f* is equal to one-quarter of the length of the circumference of the given circle, very nearly. In a 12-inch circle, this length is only about $\frac{1}{64}$ inch too short.

An almost exact result is obtained if we first find the length *f g* of Fig. 2, and then make *d f* of Fig. 4 equal to it. In a 4-foot circle the result will then be only about $\frac{1}{64}$ inch short; and in a 1-foot circle the discrepancy will be only one-fourth of $\frac{1}{64}$ inch, an amount that is hardly perceptible.

WATER CONSUMPTION OF STEAM ENGINES.

George A. Goodenough.

IN estimating the performance of a steam engine, we usually employ, as a basis of comparison, the number of pounds of water used by the engine per hour for each horsepower developed. Thus, an ordinary slide-valve engine uses perhaps 35 or 40 pounds of water per horsepower per hour; the best triple-expansion pumping engine uses perhaps not more than 12 to 15 pounds; a direct-acting steam pump may use 100 pounds or more. The absolute economy of a steam engine, so far as coal is concerned, is measured directly by the water consumption, and, other things being equal, the best engine is the one that uses the least water per horsepower per hour. However, the water consumption is not an unfailing test of the good or bad qualities of an engine. For example, take two engines, one a non-condensing engine using steam at a pressure of 85 pounds per square inch; the other a condensing engine using steam at a pressure of 135 pounds. Suppose the first engine consumes 25 pounds, and the second engine 20 pounds, of water per horsepower per hour. The performance of the first engine is relatively much better than that of the second, although its steam consumption is greater.

To obtain a just idea of the merits of an engine we must compare its water consumption with that of an ideal steam engine working under the same conditions. By the term *ideal steam engine* we mean an engine in which there are no losses due to radiation of heat, cylinder condensation, etc. The steam entering the engine cylinder brings in a certain quantity of heat, and the steam departing through the exhaust takes away with it a *less* quantity of heat. The difference between these two quantities is the heat available for doing the work of moving the piston. For instance, suppose the entering steam brings in 600 units of heat, and in the same time the exhaust steam carries out 450 units, then the difference, 150 units, may be used in doing work. The ideal engine utilizes all of these 150 units; but in the ordinary steam engine it may be that 30 or 40 units are wasted by radiation, condensation, friction, etc. The ideal engine does not, of course, exist in practice; it, however, furnishes a standard which should be approached as nearly as possible. The most meritorious engine is the one that most nearly approaches this ideal.

The water consumption of the ideal engine depends entirely upon the pressures of the entering steam and the exhaust steam. In the accompanying table, the water consumptions have been calculated for both condensing and non-condensing engines. The pressure in the condenser is assumed to be 2 pounds per square inch above vacuum; and for the non-condensing engine the pressure of the exhaust is assumed to be 16 pounds per square inch above vacuum. In the first column is given the gauge pressure of the entering steam, and in the second column is given the pressure above vacuum, which is obtained by adding the pressure of the atmosphere (14.7 pounds per square inch) to the gauge pressure.

Condensing Engine.			
Pressure of Steam by Gauge.	Pressure of Steam Above Vacuum.	Pressure of Exhaust.	Water per Horsepower per Hour.
5.3	20	2	17.3
45.3	60	2	12.7
85.3	100	2	11.3
135.3	150	2	10.4
185.3	200	2	10.0
235.3	250	2	9.6
285.3	300	2	9.4
485.3	500	2	8.9
Non-Condensing Engine.			
Pressure of Steam by Gauge.	Pressure of Steam Above Vacuum.	Pressure of Exhaust.	Water per Horsepower per Hour.
5.3	20	16	158.1
45.3	60	16	27.7
85.3	100	16	20.3
135.3	150	16	17.1
185.3	200	16	15.4
235.3	250	16	14.3
285.3	300	16	13.6
485.3	500	16	12.1

This table furnishes the required standard by which we may judge our engines. We have, for example, a non-condensing engine using steam at 85 pounds gauge pressure.

Referring to the table, we see that the water consumption of the ideal engine under these conditions is 20.3 pounds per horsepower per hour. This is the smallest possible quantity of water for an engine working under these conditions; if, therefore, our engine uses only 25 pounds per horsepower per hour, we consider it a fair performance; if it uses only 22 pounds, we consider it a remarkable performance.

A study of the table discloses some noteworthy facts. It is readily seen that the greater the difference between the pressures of the entering steam and exhaust steam, the smaller is the water consumption; thus, to obtain a low water consumption, we raise the pressure of the live steam as high as possible and make the pressure of the exhaust as low as possible. It appears, however, that after passing a certain point a large increase in the steam pressure gives a relatively small decrease in the water consumption; thus, raising the pressure from 300 to 500 pounds lowers the consumption of the non-condensing engine from 13.6 to 12.1 pounds, a decrease of 1.5 pounds. If we keep the steam pressure at 300 pounds, and lower the pressure of the exhaust, by means of a condenser, from 16 to 2 pounds per square inch, the water consumption is lowered from 13.6 to 9.4 pounds, a decrease of 4.2 pounds. Lowering the exhaust pressure 14 pounds per square inch produces nearly three times as great a decrease in the water consumption as raising the steam pressure 200 pounds per square inch. This fact shows that the pressure in the condenser is a very potent factor in the economy of the steam engine, and that a slight lowering of the condenser pressure has much more influence on the economy of the engine than a considerable increase in boiler pressure.

WHAT IS A MECHANICAL ENGINEER?

WE OFTEN hear this question asked, but there is generally a great deal of hemming and hawing over the answer. The fact is, very few people outside of the profession know what a mechanical engineer is, and even those who know are apt to speak hesitatingly when trying to tell anybody. And why should there be so much doubt about the meaning of the title? It is not so with other professions. When a man says he is an architect, we know at once what he means; so, also, if he is a physician, surgeon, lawyer, actor, or artist, and most people know what a *civil* engineer is, but are all at sea when it comes to mechanical engineering; and yet our universities are annually turning out hundreds of men who graduate as mechanical engineers and write M. E. after their names. The question is, what do these men know? What can they do? Well, they have studied mathematics in all its branches, theoretical and applied mechanics, hydromechanics, pneumatics, heat, steam and the steam engine, boilers, strength of materials, machine design, and, possibly, chemistry and metallurgy. They have also become proficient as mechanical draftsmen, and they have had some practical experience in the pattern shop, foundry, and machine shop. Broadly speaking, these studies have given them a knowledge of Nature's laws governing the motion of matter, be it solid, liquid or gaseous, of the transmission of forces, and of the properties of the materials which Nature has given them, as well as of mixtures of these materials, principally metals, which experience has taught us can be made.

Knowledge of this kind has enabled mechanical engineers of the past to give us innumerable machines for the manufacture of textile materials with which to clothe ourselves or decorate our homes; agricultural implements for tilling the soil, grinding grain, and preparing food; locomotives for mechanically hauling these products across country; steamships for ocean transportation; in fact, an almost infinite variety of machines that are daily producing, or helping in the production of, everything we eat, wear or use, as well as the many labor-saving appliances with which every one is more or less familiar. And mechanical engineers of today, with the additional and higher knowledge that scientists are constantly giving to the world, are busy improving machinery long since invented, and designing new machines for the use and benefit of posterity.

PHOTOGRAPHING A RIFLE BULLET.

E. W Roberts.

ORDINARY INSTANTANEOUS PHOTOGRAPHY—NO SHUTTER FAST ENOUGH TO CATCH A RIFLE BULLET—THE SPECIAL APPARATUS EMPLOYED—AIR WAVES APPEAR ON THE PICTURE.

FIG. 1.

THE ordinary camera, with its swiftly moving shutter, is sufficiently rapid for photographing such objects as running animals, persons walking, and, in some cases, fast moving trains. The photographing of a bullet just started from a gun is, however, quite out of the question with an ordinary camera.

It will be well to consider for a moment how short the so called "instantaneous" exposure must be when photographing moving objects. Leaving out of the question the matter of the sensitiveness of the plate, which in this case becomes of minor importance, let us see how far the image may be allowed to move on the plate without injuriously blurring the picture. An examination of several instantaneous photographs will show that a movement of more than $\frac{1}{100}$ of an inch makes a blur sufficient to destroy the distinctness of small objects, while for sharp pictures $\frac{1}{200}$ of an inch is often the largest possible allowance.

Suppose we wish to photograph a locomotive moving at the rate of 60 miles an hour; let us take a case where 1 inch on the picture will represent 15 feet on the locomotive. Then the image travels only 1 inch while the locomotive is going 180 inches. A speed of 60 miles an hour is equivalent to 88 feet per second, and the image in the camera would be moving at the rate of $88 \div 180 — .49$ feet, or, say, 6 inches per second. In going $\frac{1}{200}$ of an inch, the image would take only $\frac{1}{200} \div 6$ or $\frac{1}{1200}$ of a second.

A shutter capable of such rapid work is seldom needed, even when photographing fast moving trains, because the camera is usually placed close to the track, with the train coming almost directly towards it, and the speed of the image is comparatively slow. It is only when the camera is pointed at right angles to the track that we get the speed just spoken of. Hence, a shutter giving an exposure lasting $\frac{1}{100}$ of a second may produce a good negative of an approaching train.

In the photography of bullets, the object is so small that a full sized image is desirable. With the apparatus we are about to describe, the time of exposure is so short that the bullet moves only $\frac{1}{400}$ of an inch during the exposure. Instead of 88 feet per

second, as with the express locomotive, we have now to deal with velocities of about 2,000 feet per second. Moreover, since our image is to be full size, its velocity on the sensitive plate will be the same as that of the bullet. Our time of exposure, then, becomes $\frac{1}{2{,}000 \times 12 \times 400} = \frac{1}{9{,}600{,}000}$ of a second, since there are 12 inches in 1 foot, and our image must move only $\frac{1}{400}$ of an inch.

To construct a shutter capable of such rapid work would be an extremely difficult task, if it could be accomplished at all. Fortunately, we have at our disposal a method of obtaining short exposures, which simplifies the problem very considerably. To make this method clear, let us take a spoked wheel, and set it revolving very rapidly in a dark room, then illuminate it for an instant with an electric spark; we shall find that, during the instant the wheel is visible, it seems to be standing still. This is because the electric spark lasts so short a time that the wheel makes no perceptible movement during the flash.

In Fig. 1, (*a*) shows a bullet moving at the rate of 2,100 feet per second, photographed by a spark lasting $\frac{1}{50000}$ of a second. The image shows that the bullet moved about half an inch during the exposure, and that the spark lasted too long to produce a sharp negative.

Fig. 2 is a diagram of an apparatus used by Mr. Boys, an English experimenter. This was capable of producing a spark lasting less than $\frac{1}{10000000}$ of a second. It consists of the condenser *C*, made of a sheet of window glass, on each side of which is cemented a sheet of tin foil a foot square. This instrument stores up electricity somewhat like a storage battery, but, unlike the latter, gives off its charge much more quickly, and all the stored-up energy can be put into one extremely rapid spark. And, what is still more important, the discharge of the condenser can be brought about by the bullet itself, just as it is passing the sensitized plate.

Referring again to Fig. 2, *c* is a small Leyden jar, another form of electrical condenser, connected to the right side of *C* by a metallic conductor *g*. The other terminal of *c* is connected to the left-hand plate of *C* by means of a wet string, shown by the dotted line *h*. *E* and *E′* are gaps in the circuit; condenser *C* is charged to such a point by means of a static machine that it will spark across either gap when the other is closed, but not sufficiently to enable the discharge to bridge both gaps at once. The wet string *h* keeps *C* and *c* at the same pressure, though it is of too high a resistance to allow *C* to discharge through it rapidly.

Now, suppose we close the circuit of *c* by some such means as the bullet *B*. *c*, being strong enough to bridge gap *E′*, discharges by *g*, *b*, *d*, *e*, *B*, and *f*. As soon as a spark is formed at *E′*, the resistance of the gap becomes less, and *C* immediately discharges through *b*, *d*, and *a*. There will, of course, be a small spark formed at *B* when condenser *c* discharges, but not of sufficient power to affect the plate. It is the large spark at *E* that produces the picture, by casting a shadow of the bullet and surrounding objects upon the plate at *P*. The entire spark at *E* does not last longer than one-millionth of a second, while the brighter portion, which makes the picture, lasts less than one-tenth of that time, or about $\frac{1}{10000000}$ of a second.

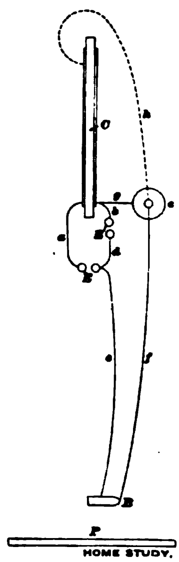


FIG. 2.

Fig. 3 shows a laboratory fitted up for photographing rifle bullets. Those parts of the apparatus shown in Fig. 2 are indicated in Fig. 3 by the same letters. In addition to these, we have the rifle securely clamped to the bench at *R*. The bullet, which takes the course indicated by the dotted line, is photographed when at *B*. The gap *E* is just inside the right-hand end of *X*. The tube *T*, by which the bullet enters *M*, is painted a dull black, as is also the inside of the box *M*, so that practically no daylight reaches the sensitive plate. The bullet first pierces a card over the end of *T*, and, after passing through *M*, enters a long box *S*, filled with bran, where it is stopped without being bruised. At *H* is shown the induction machine for charging the condensers.

The operator first gives the induction machine a sufficient number of turns to store up just enough energy to surely spark across one gap, but not across both; experience only will tell him how many turns. The lid of *M* is closed, and the slide of the

FIG. 3.

plate holder *P* withdrawn. The rifle is then fired, and the spark at *E*, inside the box *X*, produces a shadow impression of the bullet on the plate.

Referring now to Fig 1, (*b*) shows a bullet from a Martini-Henry rifle, caught while going 1,295 feet per second. This picture shows the ends of the wires *e* and *f* (Fig. 2), and a curved line in front of the bullet. This curved line is a compression air wave.

The air waves in (*c*) are much more inclined because the bullet is moving much faster, namely, 2,000 feet per second. The normal velocity of air waves is the same as that of sound, about 1,100 feet per second, and the faster the object moves, the more these waves will trail behind. If the bullet moves slower than 1,100 feet, no air waves are seen.

The blur in front of the bullet is probably caused by particles of the cover of tube *T*, Fig. 3. Some of these are also seen trailing behind. Note how sharp these images are, and compare them with that shown at (*a*).

At (*d*) a bullet is shown passing through a mixture of carbonic acid gas and vapor of ether. Note the sharp angle of the air waves, and compare with (*c*). Sound travels much more slowly in this mixture of gases, and the "air waves," consequently, have a greater tendency to lag behind.

At (*e*) is shown a photograph of flying shot, with a wad following. There are, in this picture, a great number of wavy lines. It is supposed that they are formed by the powder gases, since the velocity of the shot is too slow to form compression waves.

Figs. (*f*), (*g*), and (*h*) show the passage of a rifle ball through a pane of glass. The first shows the bullet just as it strikes the glass. Note the backward splash of splinters, and the cloak of splinters forming about the head of the bullet. At (*g*), the bullet has passed completely through the pane. It is now entirely surrounded with glass, and is leaving a comet-like tail of splinters behind it. In Fig. (*h*) the bullet is seen to have shaken off nearly all its former companions. Above the ball is seen a small patch of glass keeping pace with it.

The different varieties of air waves form an interesting study by themselves. It will be sufficient for this article to note that the faster the bullet, or the more dense the medium through which it is passing, the sharper will be the angle made by the waves.

BATTLING WITH BARNACLES.

Ernest K. Roden

WINDS AND WAVES ARE NOT THE SAILOR'S GREATEST FOES—BARNACLES AND HOW TO GET RID OF THEM WHILE AT SEA—A NOVEL APPLIANCE.

THE average landsman knows little of the many difficulties the sailor has to overcome in order to successfully navigate the vessel that is entrusted to his care. He has to battle with furious storms of wind that sometimes threaten to blow his ship to pieces, and which would take his breath away should he dare to turn his face squarely toward the wind; he has to guide his ship through gigantic waves, frowning and choppy, that would be more than delighted to put on the "finishing touches" to the destructive work of the hurricane. These winds and waves, his chief obstacles, the navigator who understands the laws of storms, knowing how to avoid their centers, masters with comparative ease, especially when he has plenty of sea room and is in command of a vessel built to stand rough and heavy weather.

But there are other troubles than these—troubles too numerous to mention here—troubles that seem insignificant to the "land-crab," but that mean a good deal to the sailor. Among the very worst of these is a certain little animal that lurks around the vessel, beneath the surface of the water. Its size ranges from that of a pin's head to 2 or 3 inches in length, and millions of dollars are yearly spent to fight it. This seemingly harmless little creature, commonly known as the *barnacle* is illustrated in Fig. 1.

FIG 1.

And why, the reader will ask, should so insignificant a creature be honored with the outlay of millions of dollars? The reasons will be manifest as we proceed.

Ask a sailor or a shipowner if he knows what a barnacle is, and you will see a peculiar smile play over his lips, and you will hear him murmur harsh words—all because of his antipathy to the barnacle. The reason for this antipathy is that, next to the shipworm and the date-shell, the barnacle is his greatest enemy.

Unquestionably, the *Teredo navalis*, or shipworm, is, to wooden vessels, the most dangerous of the three, owing to the rapidity with which it performs its destructive work, and to the fact that its ravages take place *within* the timber, and are unnoticeable from the outside except upon close and careful examination. Indeed, until we learned to coppersheath our ships, there is no doubt that many lives were sacrificed through the mischievous activity of these vegetarian mollusks. But in these days the barnacle is considered just as dangerous to the iron vessel as the shipworm was to the wooden one.

FIG. 2.—BARNACLES ON A BOTTLE.

Barnacles attach themselves to the ship's bottom—in fact to every part of the vessel that is under the water—and thus hinder its progress considerably. The writer, from his own experience, knows of ships that have been delayed for weeks in reaching their destination, because their bottoms were covered by thousands of barnacles, producing a resistance equal to having a New York garbage scow in tow. In one instance, during a trip from London to Buenos Ayres, the bottom of the ship became fouled by barnacles to such an extent that it took a strong gale of wind to increase its speed to 6 miles an hour, while at the beginning of the voyage the same vessel made from 10 to 12 miles an hour, with less wind, and the same area of

canvas set. A brief description of this little inhabitant of the high seas may prove interesting.

The scientific name of the barnacle is *Cirripedia*, which means, with *curled* or hairlike

FIG. 3.—BECALMED IN A FAIR BREEZE.

feet. Originally, the name *Lepas anatifera* was given to the ship barnacle, because of an old legend which attributed the production of the barnacle to the solan-goose, a theory so entirely untenable that it seems incredible it should have been accepted as true, and believed in for hundreds of years. Scientists went so far as to describe and even illustrate by drawings the whole process of the evolution of the sea fowl from barnacles that had attached themselves to floating pieces of wood, been carried out to sea, and cast ashore on the English coast. In 1490 the historian Hector Boece declared that he saw the larvæ of the barnacle formed into "perfect foules," and Master Gerard, one hundred and fifty years later, gave another circumstantial account of the same mysterious evolution. Indeed, even in these days of enlightenment it is not difficult to find old sailors who still cling to this theory, and emphatically declare that in their younger days they often heard "the cry of the young goose come from the barnacle."

The shell of the barnacle is bivalve in appearance, each side of it being composed of two plates connected by a long central one which joins the two halves at the back. Some varieties are closely attached to the object to which they adhere, while others are connected to it, as in Fig. 1, by a cylindrical, flexible stalk of a fleshy nature, the color of which varies from bright orange to a purplish red.

Like some other marine creatures of low order, the young barnacle is, in many ways, more highly developed than its parents. According to naturalists, the barnacle, in its first stage of existence, is furnished with a shelly covering, two pairs of antennæ, three pairs of legs, which are branched and supplied with bristles, and a forked tail, while it possesses but one small eye, which is placed in the center of its anterior part. Before attaining adult size, its shelly skin is changed three times. At the third change wonderful transformations are observed; the head is greatly enlarged and the one small eye disappears, to be replaced by two large ones; but then, when the animal seems to be equipped for enjoying a free existence, it suddenly surrenders all these advantages and sets out to find a suitable place to complete its last permanent metamorphosis. It is at this stage that the sailor wishes the barnacle would cease to exist. If it did, the happiness of both the sailor and the shipowner would certainly be greatly enhanced. Instead of dying, however, the barnacle generally selects, as its last resting place, the

FIG. 4.

lower portion of a becalmed ship or a floating piece of timber. Sometimes it affixes itself to a whale lying at ease, or to the back of a

turtle—in fact, to any hard, firm substance that is suitable for its accommodation. One would imagine that in the ever-moving waters of the ocean it would be no easy task for the barnacle to attach itself to the bottom of a ship or to any kind of sea animal; that, though the ship were becalmed, it would still possess a motion sufficient to prevent the barnacle from getting a "hold." Such, however, is not the case, and the secret of this lies in the ability of the barnacle to produce a wonderful cement, which is insoluble in water, and which enables the animal to affix itself to any object it selects. This cement is a kind of organic gum that the barnacle pours out when coming in contact with a floating object, and which becomes hard immediately; with this it firmly secures itself to the ship's bottom, to the resting whale, or what not for the remainder of its life.

Having come to rest, further transformation of the animal takes place. Its bivalve shell is dropped, and its eyes, henceforth of no use, are discarded; the head lengthens and the new shells are five-plated. The legs are changed into curling tendrils (see *a*, Fig. 1), and are now used mainly for the purpose of creating currents in order to draw food towards its mouth.

FIG. 5.

Such is the barnacle, which, through its adhesive power, has more than once compelled the mariner to live on half rations and to drink filthy, stagnant water, even though a strong and favorable wind has been blowing. No wonder, then, that he despises it, and that he has devised many means by which to get rid of it.

Of course, the most effective cure is to take the ship into dry dock and scrape the barnacles off; and usually this is done after the ship has completed a long voyage. But dry-docking is a costly proceeding. At sea, however, and in mid-ocean, dry docks are scarce—very scarce indeed—and there the mariner is left to his own resources.

In Fig. 4 is shown another effective method of cleaning the bottom of a ship from barnacles; the vessel is pulled up on to what is generally known as a marine railway and thoroughly scraped and cleaned.

Fig 5 illustrates one method of removing barnacles while the ship is at sea—a very simple method, but, unfortunately an ineffective one. It consists of a three-cornered scraper, fastened to the end of a long pole,

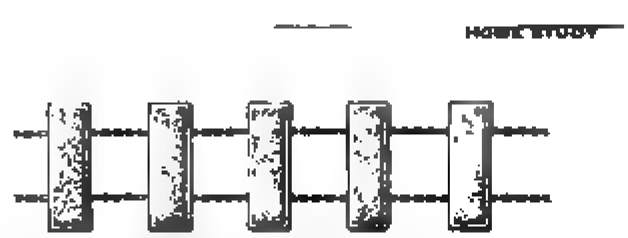


FIG. 6.

and is operated by one man. Only a few feet below the water-line can be cleaned off in this manner, and, if the vessel is lightly loaded, that is, if the hull is high above the water, the method is practically useless.

Another way and a more effective one is shown in Fig. 6. A number of steel brushes are fastened to two parallel chains, about 5 or 6 feet apart. The chains are then taken around and underneath the ship's bottom and connected by tackle on each side. By pulling the tackle on one side and slacking it on the other, and vice versa, a back-and-forth motion is produced, a considerable

portion of the bottom being thus cleaned; but it is slow and heavy work Several men must be engaged in it, and after all only the amidships sections show any improvement. The fore part and after part cannot be touched by this contrivance, and, besides, it is always menaced by the keel *k*, which prevents the

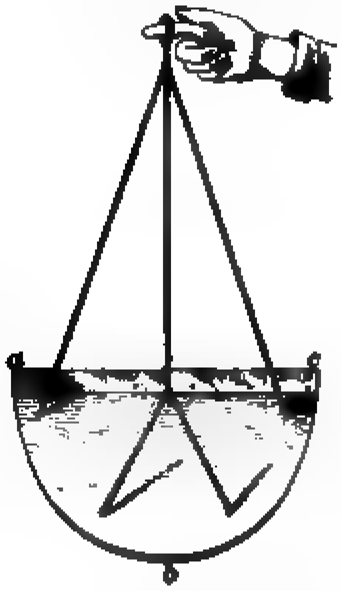


FIG. 7.

portions *a* and *b* from ever being reached by the brushes. Yet this "chain-scrubbing," as it is called, is practiced by many seafaring nations, especially on Greek and Italian vessels.

During the trip already mentioned, from London to Buenos Ayres, the writer succeeded in constructing a quite effective weapon which was successfully used in the never-ending campaign against the barnacle. The vessel in which this voyage was made was built of iron, had a considerable beam,

regions of little or no winds were again encountered; and all the while the barnacles grew rapidly under our feet.

To add to this, the ship was not equipped with materials for rigging up a "chain scrubber," so the only thing that could be resorted to was the pole and three-cornered scraper. At last, when the breeze did come, the ship was hardly able to crawl through the water at the rate of from 3 to 4 knots per hour. Provisions began to give out, and the situation became rather "close."

But in this case, as in many others, the old saying "Necessity is the mother of invention" proved true. After considerable experimenting, a scraper was constructed on the same principle as a kite. It was a very simple affair. The scraper itself was a semicircular board of oak *a b c*, Fig. 7. The length of the upper edge *a c* was 3 feet. To this edge was fastened a piece of hoop iron, and the whole was attached to a "crow" made of 1-inch hemp rope and arranged as shown in the figure, thus giving the scraper an inclination of about 45 degrees.

Fig. 8 shows how this new contrivance was operated. A snatch-block was fastened at *a*, and through it was run a rope, one end of which was taken under the vessel and handed to the man stationed at the extreme end *b* of the quarter-deck, while the other end was led to the capstan *c* on the forecastle. The man stationed at *b* then connected his end of the rope to the "crow" on the scraper, and also fastened a guide line to it. Then a signal was given and the men

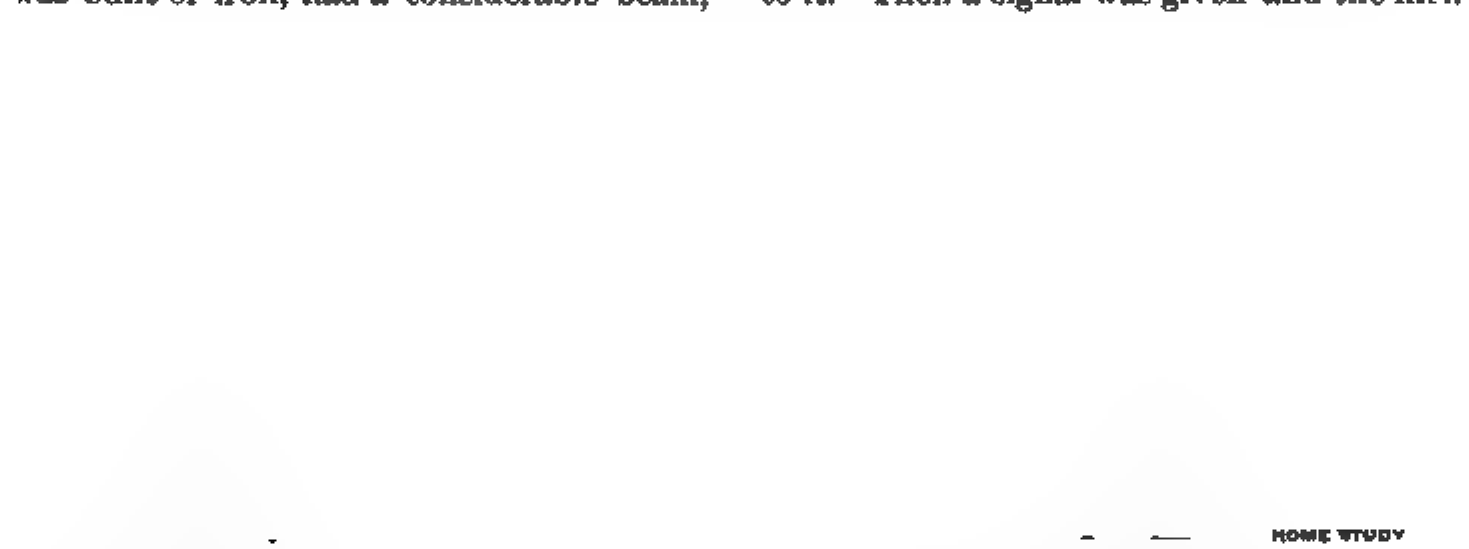


FIG. 8.

and a rather flat bottom, as it was intended for service in shallow water; it was therefore a "Mecca" for barnacles. In consequence of reverse winds and much calm weather, the equator was not crossed until after sixty days had been passed at sea; then, after entering the Southern hemisphere,

at the capstan began to heave in. With his guide line the operator at *b* controlled the scraper until it reached the surface of the water, after which it took care of itself—as well as of the barnacles.

Its inclination and forward motion caused it to keep close to the bottom of the ship,

and it made a clean shave from aft to fore, faithfully following the curvature of the bottom. After having completed its tour to the bow, the headline was let out, allowing the operator at *b* to pull back the scraper with his guide line and apply it to a place next to where he first applied it, thus preventing it from following its former path. This maneuver was repeated again and again, the operator gradually working his way width by width forward, as indicated by the dotted lines *m*, *n*, *o*, *r*, and *s*, the weight of the headline giving the scraper a downward tendency. In this manner, and by changing the snatchblock to different positions at the bow, so as to insure the scraper touching every part of the bottom, the barnacles were, within a week, successfully routed, the best evidence of this being the fragments of their shells strewn in the wake of the ship, while at the same time the speed of the ship increased, much to the satisfaction of the ship's steward and men.

Naturally, this cleaning off was not as perfect as if it had been performed in a dry dock, some narrow strips possibly being left; but then, it was done some six hundred miles from the nearest shore, and with facilities that hardly amounted to anything.

The most advantageous time for operating the scraper is when the vessel is making a headway of from 2 to 3 knots, it being then unnecessary to heave or pull in the headline very quickly as is the case when the vessel is at a standstill. Furthermore, the lee side is always easier to work than the windward. When using this scraper on wooden or copper-sheathed vessels, a couple of rollers should be inserted, about half an inch in diameter, so as to prevent the cutting edge from touching or ripping up the seams or from catching on to nail heads.

Some time after this voyage was made, and while temporarily engaged with the Black Sea division of the Russian navy, the writer again had an opportunity to demonstrate the usefulness of this contrivance on the foul bottom of the torpedo-transport boat "Donaj." This time the scraper was made wholly of steel, and the result turned out quite satisfactory, as was afterwards proved when the vessel was docked.

Much experimenting has been done of late in shipping circles in attempts to produce a paint to be used on ships' bottoms, of such a nature, chemically, as to prevent the barnacle from establishing a permanent home on the bottoms of becalmed vessels, but as yet the problem has not been satisfactorily solved.

BREAD.

W. P. Smiley.

The History of Bread—Bread of the Indians—The Chemistry of Bread—Making and Baking—Tables Showing Constituents of Bran, Flour, and Bread.

The daily bread, for which all are toiling, has been eaten from the earliest times. Since those days, however, it has undergone great improvements, and the ancients would scarcely recognize the fine white loaf of today as the descendant of their coarse cakes.

The most primitive method of making bread was to soak the grain until it became soft, and dry it either by natural or by artificial heat. The next step was to grind the grain between stones, mix it with water, and dry or bake it. Thus, the American Indian in recent times ground his corn in a stone mortar, mixed the coarse meal so obtained with water, and baked it on a hot stone. And it is from such rude beginnings that the fine white bread of the present has come.

Ordinarily, the manufacture of "the staff of life" is not thought of as a chemical process, for the art of baking is older than the science of chemistry, and the chemical principles that underlie the whole process were applied long before they were understood. But, since these principles have become known, great improvements have been made in the art, which have made the process easier and the product better. Crœsus, with all his wealth, could not purchase such bread as the workingman of our times eats daily as a matter of course.

Bread is made in different countries from different grains. In Scotland oats are largely

used, in Germany rye bread is common, and in parts of this country much corn bread is used. Barley and rice are also used, but wheat is by far the most largely used of any grain in making bread; and when the flour or meal of one of the other grains is to be used it is generally mixed with wheat flour.

If flour is mixed with water, a pasty mass results that is unpalatable, and nearly indigestible, and if this is merely dried it is not much improved in either respect. Its physical and chemical form must be changed: the physical form, in order that as much surface as possible will be exposed to the juices of the mouth and stomach, and the chemical form in order that it shall be attacked and dissolved by these juices.

According to Bloxam, *whole-wheat flour* contains:

Water	12.1
Starch	60.8
Gluten	10.5
Dextrin and sugar	10.5
Albumen	2.0
Woody fiber	1.5
Fat	1.1
Mineral matter	1.5
	100.0

Whole-wheat flour is made by grinding the entire kernel of the wheat as it comes from the threshing machine. This grinding process is not the ordinary one, however, the process in general use being that in which, during the milling, the different parts of the wheat are separated into white flour, or the interior of the wheat, and bran, or the outer covering of the grain. Each contains nutritive matter. According to the well known chemist Mr. A. H. Church, the composition of the two products is as follows:

	White Flour.	Bran.
Water	13.0	14.0
Fibrin, etc.	10.5	15.0
Starch, etc.	74.3	44.0
Fat	0.8	4.0
Cellulose	0.7	17.0
Mineral Matter	0.7	6.0
	100.0	100.0

These constituents of flour may be divided into water, carbohydrates, nitrogenous compounds, and mineral matter. Water and the carbohydrates, such as starch, sugar, and cellulose, are fat-forming compounds; the nitrogenous matter, such as fibrin, etc., tends to form muscular tissue, and the mineral matter, consisting largely of phosphates of calcium, potassium, and sodium, goes largely to build up the bones.

The bran is rich in nitrogenous food products and mineral constituents, but is usually separated from the flour because it would make the bread darker colored, and more difficult to digest; it also contains cerealin, a ferment which acts strongly on the starch, rapidly converting it into dextrin, and other soluble bodies, thus rendering whole-wheat flour unsuited for use by the ordinary process. Bread made in the usual way, from whole wheat, does not keep well, but, owing to the decomposition mentioned, soon acquires a sour odor and taste.

The carbohydrates in flour, consisting of starch, sugar, cellulose, and dextrin, form about three-quarters of its weight. The nitrogenous matter contains at least five compounds, three of which—gluten, mucin, and fibrin—are known as crude gluten, and constitute the greater part of the substance which remains on separating the parts of the flour that may be washed away by water. This washing may be accomplished by mixing flour with water, thus making dough, which is placed in a piece of fine muslin and kneaded under water. The soluble portions will be dissolved by the water; the starch will be suspended in the water and will pass through the cloth; and the gluten will remain as a tough, elastic mass. The other two nitrogenous bodies—vegetable albumen and cerealin—are soluble in water, and are thus washed out with the carbohydrates. Crude gluten is very tenacious. It holds the whole together, and prevents the escape of carbon dioxide, thus rendering wheat flour very well adapted for the purpose of bread baking.

The first step in making bread is to mix flour with water. As soon as it is wet, the gluten begins to decompose and acts on the starch, changing part of it to sugar, while the sugar, dextrin, and some albuminous substances are so changed that they become soluble. The solution thus formed is thoroughly mixed with the starch and gluten of the flour, and these are soaked and partly dissociated. At the same time yeast is added, which acts upon the sugar, starting fermentation. It is now allowed to stand while fermentation proceeds, during which the dextrin is changed into carbon dioxide and alcohol. The carbon dioxide causes the mixture to expand and become spongy.

Yeast is a vegetable ferment, developed from minute germs which float in the air. When these come in contact with a liquid containing the proper nourishment, they rapidly grow into chains of oval cells. During this growth, yeast has the property

of changing sugar into carbon dioxide and alcohol, a process known as *fermentation*. The yeast plant is skimmed off the liquid, mixed with a little starch and pressed into cakes, when it is called *compressed yeast*.

After standing for some time in a warm place, the *sponge*, made as described above, is mixed with more flour until the proper consistency is obtained, and is then kneaded. This operation compresses the dough, which must again be set aside in a warm place, while the flour which has been partly changed acts on the new flour, and fermentation proceeds. The carbon dioxide formed causes the dough to rise, while the insoluble materials are being changed to soluble ones. This process having been carried far enough, the dough is placed in an oven, which should be heated to about 400° to 450° F.

The surface of the loaf is often moistened with water just before placing in the oven, to aid in the formation of a crust, which prevents the too rapid expansion due to heating the gas contained in the dough. The moisture and heat rapidly convert the starch upon the surface of the loaf into dextrin and maltose, which, at this high temperature are partly changed to caramel, giving the crust its brown color. In the interior of the loaf the starch cells burst, and the albuminoids are coagulated, thus stopping fermentation. Thus, by this process, the constituents of flour are obtained in a soluble and digestible form; and the presence of carbon dioxide makes the flour quite spongy, so that a large surface is exposed. Bread thus made has also an inviting appearance, and a pleasant taste.

The temperature of the interior of the loaf does not rise much above 212° F. during the baking, but this is sufficient to break the starch cells and render it more easily digested. But at the surface the greater heat causes a greater chemical change. Von Bibra gives the following as the composition of the crust and the interior of the bread:

	Inside.	Crust.
Starch	67.871	68.077
Nitrogenous Matter	11.296	10.967
Dextrin and Soluble Starch	14.975	16.092
Sugar	4.175	4.149
Fat	1.683	.715
	100.000	100.000

Various substitutes for yeast are used in baking bread, but none of those so far proposed seems to be entirely satisfactory. Leaven is sometimes used. This was possibly the first ferment employed in making bread. The leaven of the Egyptians and Israelites was probably the same as that used today, which is made by mixing flour with water and allowing it to decompose. Its use gives the bread a darker color. If the leaven is in the proper stage of decomposition, it will start alcoholic fermentation; but acid fermentation soon starts up, and, if leaven has arrived at this stage, acid fermentation is induced in the dough, which becomes sour and heavy. Acid fermentation is a kind of decomposition in which acid is formed instead of alcohol. When this takes place in the dough, it is corrected by adding a compound commercially known as *saleratus*, which consists of bicarbonate of soda, or potash. This neutralizes the acid, and at the same time sets free carbon dioxide, which causes the bread to rise.

In the methods given, the carbon dioxide is obtained at the expense of some of the starch and sugar of the flour, and, to avoid this, and at the same time shorten the process, Liebig proposed the addition to the dough of bicarbonate of soda and hydrochloric acid, which would set free carbon dioxide and leave common salt in the bread. This led to the introduction of the various baking powders, by the use of which bread can be made in much less time; but none of those thus far proposed has been able to displace yeast.

We have seen that whole-wheat flour contains a greater amount of flesh-forming and bone-forming material than white flour, but is not so well adapted for a food material, owing to the fact that bread made from it is less attractive in appearance than that made from the white flour, and is harder to digest, while the nutriment it contains is less easily assimilated.

Other grains are also richer in certain kinds of food material, but none of them makes such attractive looking bread; and, owing to a difference in the gluten, none of them is so well fitted to retain the carbon dioxide, and form a spongy, easily digested bread. This is partly overcome by mixing other flour or meal with wheat flour, thus getting the advantage of the tenacious wheat gluten. But anything mixed with wheat flour tends to diminish its nutritive value, and makes it less easily digested; so that probably, when everything is considered, white bread is the best single article of diet that, at the present time, is produced.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

A Suggestive Vacation in London.

London in the Thirteenth Century

IN THE early part of the current year, when the Spanish-American war was imminent, and even for a few weeks after hostilities began, it was thought that the annual exodus to Europe of American holiday seekers would not take place, and that the great transatlantic steamship lines might go out of business, as far as passenger traffic was concerned. There was no doubt as to the ultimate outcome of the war, but its duration was uncertain; as long as it lasted, business interests would be disturbed; and property, especially on the eastern seaboard, was thought by alarmists to be in danger.

Until the attitude of Europe towards the United States had been determined by the firm stand which Great Britain took, and by her outspoken expressions of friendship for her own kith and kin, none knew what assistance—moral or material—might be given to Spain, nor how the position of American tourists on the Continent might be affected by the action of the various governments. Prudent people resolved to stay at home, or to travel in their own country. But, as the weeks of May and June went by, the face of affairs changed; all doubts as to the safety of persons and property were dispelled; and the magnetic attraction of the Old World for the New—that curious illustration of the constant action of centripetal and centrifugal forces—was felt as strongly as ever. Diminished passenger lists there may have been; men and money were wanted in other directions; but thousands traveled, and traveled for pleasure. To some the journey was an annual excursion; to some the event of a decade, perhaps of a lifetime; but, whatever his condition, the observant traveler returned with a widened view of the world, of men, and of manners, and with a stronger realization of the closeness of the bond existing between the interests of mankind in the past and in the present.

A human past of a score of centuries lives there in the concrete, and the sources whence have sprung the laws, the customs, and the aspirations of modern life are, to intelligent eyes, visibly displayed. The student of the current history of his own generation can read in the cities, the buildings, and the institutions of the Old World the current history of a bygone day. The march of modern improvement has yet spared a few material witnesses to the energies of men who in past centuries simply did their daily work as we do, and thought no more (perhaps even less) of making history than we do today. The scanty and destructible written chronicles of the past are supplemented by these records of stone, and by ancient usages which still survive, testifying to the force and character of the institutions by which our forefathers were molded and prepared for the work that lay before their race.

It used to be said of traveling Americans that they simply passed through England on their way to Paris, that they did not like England or English surroundings, and had no desire to linger in the country. This statement, if it ever were true, is becoming less so year by year, and but for remarks in old journals of travelers would hardly be believed. However varied may be the sources of the population of the United States, it remains a fact that the fountainhead is Anglo-Saxon, and that the laws and the constitution of the country bear the marks of that people. For the large majority of American travelers, therefore, Great Britain, and the heart of Great Britain—London—ought to possess a special interest. Within the boundaries of London can be seen, in actual, tangible form, as in a museum or on the pages of a picture book, the consecutive history of our race for a thousand years. And when the sightseer turns from the walls of the White Tower, which were reared in the year 1078 by William the Conqueror, he knows that beneath his feet are the remains of a Roman city which in William's time was already eight hundred years old. Its outline can be traced; portions of the wall which surround it exist; a Roman bath has been discovered and restored; relics of an old civilization are found in the soil and in the bed of the river; the piles on which the Roman bridge was built were found embedded in the mud when a new bridge was erected in 1825–1831. London may be described as a Roman city built on the site of a British stronghold; destroyed by the Saxons, and restored by Alfred the Great a thousand years ago; and since his time its history has been continuous.

It is this continuity which gives to an ancient city a special interest in the eyes of the thoughtful observer of social and historical institutions. The interest is increased when, as is the case in London, its vigor has been sustained throughout the centuries; when it has been the leader in great national movements, the center of national life, the true capital city of the country. With all its antiquity, London is full of life, and gives no sign either of failure or of decrepitude. Midway between the tower of William the Norman and the Cheap, the medieval marketplace—where Distaff Lane, Garlick Hill, Bread Street, Honey Lane, Milk Street, and many other descriptive names still mark the spots where booths were laden with supplies for every-day needs eight hundred years ago—stands that essentially modern institution, the Bank of England, which is called the clearing-house of the world. It responds to every fluctuation in the finances of all civilized communities, and exercises a controlling influence over the money markets of the present day. A clever writer once spoke of "that exquisite nerve center of modern civilization, the pocket"; and what the pocket is to the individual man the Bank of England is to the commerce of today.

The Lord Mayor of London is the direct successor of the portreeve (who performed for the city similar duties to those which devolved on the shire-reeve, or sheriff, in connection with the county), to whom William the Conqueror gave a charter, still in existence, guaranteeing the liberties of the citizens; and he is also the successor of the mayors who have ruled the city under that name since Alwyn Child (or Henry Fitz-Alwyn) took office in 1190; he is, moreover, also a prominent and successful nineteenth-century merchant, who works in the Mansion House as diligently as ever he did in his shop or his counting-house, and administers the business of the city during his year of office with a firm hand. He may wear as his official robes curious medieval garments, and be installed amid strange trappings and quaint ceremonies; but he is a modern business man, and the sword of state which he bears on occasion is very truly symbolical of the resolution with which he defends the ancient rights and privileges of the city, and maintains order within its precincts.

His jurisdiction, however, is limited. London—the largest city in the world, with

an area of 690 square miles, and a population (1891) of 5,633,000, increasing at the rate of 70,000 per annum—has in its center a core—a nucleus—of a little more than one square mile in extent, the ancient city of London; and it is this, and this alone, which is under the authority of the Lord Mayor. When the Londoner speaks of "the City" he refers only to this small section of the metropolis. It is generally known that the word *city* has in England a signification different from that which prevails in the United States. It invariably means a corporate town that is, or has been, a bishop's see. So the little town of Wells, with 3,000 inhabitants, is a city; while Birmingham, with its half million, is a town. And this square mile in the heart of London is the City, while the great metropolis of which territorially it is so insignificent a part is (with the exception of Westminster) a town. Nine-tenths of the day population of the city are absent at night, leaving their valuable property in the care of the eight hundred police, the successors of the "watch," instituted or reestablished, as we are told by the old Elizabethan chronicler Stow, by Harry III in the year 1253, "for the better observing of peace and quietness." The student of early municipal government and of its development, who has chosen London as his object lesson, sees his limits clearly marked out. He can devote himself to the twenty-six wards into which the old city is divided, and avoid the distractions and the complications of the great mass by which it is surrounded.

The ordinary visitor finds many interests in the modern aggregation of towns and villages which now compose the colossal capital; in the West End with its parks and palaces, its broad avenues and fine buildings, and its many signs of life and growth—which, however, are equaled and surpassed in other great modern cities. The student of social science may be drawn to the East End, where multitudes are laboring in factories and docks and warehouses; or to the outskirts, where are found hundreds of miles of streets of small houses for the clerk, the tradesman, or the artisan whose skill raises him above the fear of want, which haunts so large a proportion of the army of labor. But there are not a few who, impelled by imagination and reflection, turn their steps towards the quarter which is so crowded by day, so quiet on Sundays and at night—the narrow streets and lanes of the London of the Normans and the Plantagenets and the Tudors; to the spot where the citizens gathered in folkmote for free and open discussion in the days of the early kings; to the docks where Danish ships were moored; to the old churches (how few remain!) where twenty generations have been baptized and married and buried; to St. Bartholomew's Hospital and Abbey Church, founded in the reign of William the Conqueror's son; to Tower Hill, where some of England's best and bravest have shed their blood for the maintenance of the freedom of their country; to the site of the Tabard, whence Chaucer's pilgrims started for Canterbury; to Bankside, where Shakespeare played; to Bread Street, where Milton was born; to Smithfield, where flames consumed Queen Mary's martyrs; and to a hundred other historic spots, all crowded into this small area; and, as they tread the soil sacred to the memory of the great race from which they sprang, they feel that they are indeed at home in the city of their ancestors.

Other aspects of London will be discussed in future issues of HOME STUDY MAGAZINE.

LATEST REPORT OF THE UNITED STATES NATIONAL MUSEUM.

IN ONE of his articles concerning explorations in the Arctic regions, Mr. Peary makes a partial attempt to explain the utility of such explorations. His explanation is rather meager, and carries with it a certain deprecatory tone, as if, while willing to accept the burden of proof, he does not wish to be pushed too hard by the utilitarian. But the history of scientific discoveries has shown that few have been made that did not later, either alone or in conjunction with others, lead to the advancement of mankind. In exemplification of this, one needs only to mention the indebtedness of modern chemistry and metallurgy to alchemy searching for a means of transmuting the baser metals into gold, for a "water of eternal youth," and for a universal solvent.

The question of utility—of what practical use will it be?—is always the first that

occurs to most people with reference to any purely abstract scientific investigation, and the investigator himself is likely to be, of all men, the least able to answer. That is a phase of the matter that he does not consider. It does not concern him. His discovery is to him only a stepping-stone—another round in the ladder by which he would "ascend the shining steeps of nature." Truth is his only quest, and the love of truth for its own sake is his incentive. He endures hardship, privation, and danger, if need be, in the pursuit of that which, so far as he can see, will have no practical value.

If, when the scientists of a century ago were prosecuting their researches into luminous, actinic, calorific, and sonorous vibrations, they had been asked to predict the practical results that they were making possible, they certainly could have given no adequate answer. It is now difficult to point out any great modern inventional achievement that is not indebted in large measure to the pioneer work of those scientists.

A naturalist at work in his laboratory, or in the larger laboratory of nature, inevitably starts in the mind of an unscientific spectator a query as to the object in view and a suspicion of serious mental defect. His scientific apparatus are toys, and he himself is a child. Think of Newton and Tyndall blowing soap bubbles! The biologist among his bacilli, the entomologist spending his life chasing insects, the archeologist digging among the ruins of buried cities, the chemist, the botanist—these all seem to the uneducated to be working without a purpose. And it is a fact, so far as most of them are concerned, that they have no definite *practical* end in view. The use, either immediate or remote, for the benefit of mankind, that might possibly be made of his discoveries, never engages the attention of a true physicist. Occasionally he comes upon something of practical value, but the discoverer rarely gains any pecuniary advantage by it. His is a case of "sowing for others to reap." His reward is the pulse-throb and the pure joy that come with discovery. It is a joy purer and higher than that of Columbus when he saw a new world rising on the horizon, but it has in it no certainty of personal profit and little promise of future honors.

Years behind these discoverers come men of practical turn, who have been slowly growing up to a mental stature such as would enable them to understand and utilize the discoveries made so long before. The physical investigator, therefore, does not prosecute his researches for the emolument of wealth and honor. He takes nature for his field. His labor is one of love. Nothing daunts him by its magnitude or difficulty; nothing is so insignificant as to quench his desire to know.

In this spirit an English chemist and mineralogist, James Smithson, left, at his death in 1829, all his wealth to found at Washington an institution for "increasing and diffusing knowledge among men." To his appreciation of the world's greatest need—knowledge—we are indebted for our Smithsonian Institute, with its annex, the United States National Museum. The testator made no attempt to indicate the kind of knowledge that was to be sought and diffused. That was to be determined by the changing needs of the world as these were interpreted by the eminent men in charge, such as Professors Henry, Baird, Langley, and others. As one reads from year to year the reports of those whose duty it has been to execute Mr. Smithson's wishes, he is impressed with the magnitude the work has assumed, and with the largeness of view in which it is carried out. In order that no important division of knowledge should be neglected, many departments have been organized, each under the care of a specialist ambitious to secure for his department the highest attainable efficiency. It is only another striking example of the advantages that come from a division of labor.

In order to illustrate the intelligent and conscientious spirit in which the testator's commission is interpreted by those entrusted with its execution, the writer needs only to cite his own experience. Many times, in the study of certain branches of natural science, he has encountered difficulties that he could not solve; found specimens that he could not classify. Upon referring them to the museum, he has in every case received the most prompt, courteous, and thorough assistance.

A farmer finds among his trees and growing crops a destructive insect that he has never before seen. Let him but send it to the museum, with or without an account of its ravages and observed habits. He may be learned, or he may be illiterate and utterly unacquainted with the technical terms of science, but an answer will surely be returned. This answer will tell him what it is, and every method known to science for protecting his interests will be pointed out. A

plant, a seaweed, a bird, a mineral, a fungus, a relic from former times, a monstrosity, anything whatever that may puzzle the scientific or the unscientific observer, will be promptly identified, and books will be indicated where further information on that subject may be found. Circulars and monographs on innumerable scientific subjects are freely sent to correspondents when there is reason to believe that they will be valued and understood.

Besides all this, if anything injurious, troublesome, or for any reason interesting, whether it be vegetable or animal, makes its appearance in any part of the country, specialists are promptly sent to study it. It would be difficult to place an adequate money value upon the work of this kind that was done by the late C. V. Riley and his assistants. The service that they rendered in many parts of our country was very similar to that of Louis Pasteur in obliterating the *phylloxera* from the vineyards of Southern France, and incidentally from those of the world.

It would be impossible, within the limits of a short paper, to give, even in merest outline, the extremely interesting contents of the latest annual report of the museum, embracing, as it does, more than a thousand pages, not including a multitude of fine cuts and beautiful reproductions from photographs. What would not Mr. Spencer have given, when preparing his "Descriptive Sociology," for two such instructive papers as those entitled "The Kwakiutl Indians" and "Graphic Art of the Esquimos." The obvious painstaking thoroughness, scholarship, and in particular the usefulness and interest, of the work, leave nothing to be desired. One naturally wishes, however, that a larger share of the vast appropriations annually made for our multiform national needs might be put at the disposal of the curators of this noblest of our educational institutions. Should one of our national legislators desire to gain for himself enduring fame and the gratitude and approval of large numbers of his most intelligent constituents, this is the end for which he should work.

HINTS TO HOUSEWIVES.

Mrs. Henry Esmond.

STAINS AND HOW TO REMOVE THEM—THE USE OF GASOLINE AS A CLEANING AGENT—CARE OF THE HANDS—CLEANING OF WALL PAPER, CARPETS, GLOVES, ETC.

IT IS an old saying and a true one that "accidents *will* happen," and every housewife, however careful she may be, knows to her cost that it is especially true in the kitchen and in the dining room. Things are always being, in some way, spoiled—utensils broken, table linen and clothing stained, woodwork marred, carpets ruined, and so on, by little accidents that it seems impossible to prevent.

The aim of this article is to show how stains of various kinds can be removed from different materials, and to give a few other hints that it is hoped will prove useful.

Grass Stains.—Fresh grass stains can be removed very easily by soaking the stained article in cold water, and rubbing vigorously; this done, you will find it hard to tell where the stain has been. Stains of long standing are not so easy to remove. Soak the stained part in alcohol for an hour or two, rubbing hard every ten or fifteen minutes. If the stain has not entirely disappeared after this treatment, repeat it; then rinse in cold water.

Fruit Stains.—These should always be removed from table linen and clothes before the articles are washed, otherwise they will become set and are then hard to get out. Stretch the stained portion over the top of a bowl, and pour boiling water through it into the bowl until the spot disappears.

Coffee and Tea Stains.—To remove coffee and tea stains, rub hard in *cold* water, and do *not* use soap, as this tends to set the stain.

Rust Stains.—Iron rust, or stains of any kind that have become well seated, can be removed with oxalic acid. Great care should be taken in the use of this agent, as it is a deadly poison. Dissolve ¼ of a teaspoonful of oxalic acid in 1 cup of boiling water; stretch the stained portion of the cloth over a bowl and scrub it briskly with a small, stiff

brush that has been dipped in the acid and water. Scrub for a few minutes, then pour some hot water on to the cloth, letting it run through into the bowl; this is absolutely necessary, as oxalic acid will eat the cloth if it is not washed off immediately. After scrubbing, put the cloth in the sun, and it will be found, when the material is dry, that no trace of the spot remains.

Axle-Grease Stains.—Axle grease, or any dark-colored grease, can be removed from linen, or any washable goods, by rubbing the spot thoroughly with lard and letting it remain overnight; then rinse with warm water (*no* soap) until the dark spot is gone; then wash in the ordinary way. If soap is used before the grease is washed out, it will set the dark spot, and nothing will take it out.

Cleaning with Gasoline: Woolen Goods.—If you wish to remove a spot from any woolen material with gasoline, always put a piece of clean old cloth under the spot; then, with another clean cloth that has been soaked with gasoline, rub the spot briskly. Use *plenty* of gasoline—and rub, not only the spot, but quite a space around it, and turn the under cloth continually. You will find that, as you rub, the grease sinks through on to the under cloth, but if you do not turn this, the grease will be soaked up again by the woolen material. When the spot has disappeared, rub the place until dry, with a clean, dry cloth. If plenty of gasoline is used, there will be no circle left on the cloth.

Silk Goods.—Where silk is the stained material, and especially if its color is delicate, it is not wise to use gasoline, for it will probably remove not only the stain but the color of the silk also; in such cases it is much better to use either chloroform or ether, for these can be used on the most delicate shades without affecting the color.

Gloves.—The secret of successfully cleaning gloves with gasoline lies in having *plenty* of gasoline and a good supply of clean, old cloths. It is useless to attempt to clean gloves with two ounces of gasoline; get a pint, at the very least. Pour the gasoline into a large bowl; put the gloves on your hands, and dip your hands into the gasoline and let the gloves get soaking wet *all over;* then wash and rub them just as though you were washing your hands in soap and water. Wet one of the pieces of cloth, and with it rub the gloves all over, especially the ends of the fingers. Keep the gloves soaking wet until you have got them perfectly clean. Unless you are careful about this, your gloves will be streaked when dry. When they are clean, rub them with the dry cloth until they are perfectly dry; then remove from the hands, pull the fingers out straight, and fold them like new gloves. Hang them in the open air in the sunlight, and in about an hour all the smell of gasoline will have left them, the gloves being as clean as if you had sent them to the cleaner. Six pairs of gloves can be washed with 1 pint of gasoline, and by cleaning them yourself you save almost enough money to buy a new pair. Very often the ends of the glove fingers become black and quite stiff from perspiration, or they may be stained with candy or something that cannot be removed with gasoline. When you find you have spots on your gloves like this, clean them thoroughly with gasoline first, and when they have been aired, put them on your hands again (one at a time); wet a small spot on a piece of old cloth, wring it almost dry and rub it on a piece of ivory soap; put it over the end of the first finger of your bare hand and with it rub the dirty spots. There should be just enough water on the cloth to moisten the soap, but use plenty of soap. When the spots are gone, dry the glove before removing it. This process will remove almost any spots that cannot be removed with gasoline.

The Washing of Woolen Goods.—Many people find it very difficult to wash woolen cloth of delicate shades, without spoiling the colors or spotting the cloth. This is because soap is used, which is very apt to change the colors in woolen goods. The only sure way to wash such cloths is with soap bark. Get 10 cents' worth of soap bark at the drug store; tie it up in a piece of muslin and put it into three or four gallons of cold water. Put this water in the clothes boiler on the fire and let it boil. When it is cool enough to use, wash the cloth in this water, without diluting it with cold water. Wash the cloth over in three or four waters, or until it is clean; then rinse in clear, warm water, and you will find the material as good as new. The writer has tried this many times, always with perfect success.

Carpet Cleaning.—Shave into small pieces one large bar of ivory soap; put it into a kettle and add 3 quarts of cold water and 2 ounces of borax. Put the kettle on the fire and stir the contents occasionally, until the soap is completely dissolved; then add 1 pound of washing soda and stir until it is dissolved. Remove from the fire and pour into a 6-gallon earthenware crock. Add enough warm water to the soap mixture to make 5

gallons. Be sure to use warm water, otherwise the soap will lump. Mix well and let it get almost cold; then add 2 ounces of ether. Stir well and cover closely, and let it stand overnight. The mixture must on no account be hot when the ether is added, or the ether will explode. It is best to stand the crock out of doors, and, when you add the ether, cover your mouth and nose, or the fumes may make you sick. Cover it closely when done, to prevent the ether from evaporating. In the morning it will be cold, and of the consistency of stiff soft soap. Have a new, stiff scrubbing brush on hand. Take out a quart or two of the cleaning mixture, put it into a pan, and have another pan of clean cold water and plenty of clean dry cloths. Dip the brush into the soap, and scrub quickly and lightly over the carpet. Do only one breadth at a time; scrape the soap off with a smooth stick, and wipe the carpet with a cloth wrung out of the clean cold water; then wipe with a dry cloth. There are a few rules in washing carpets that to be successful you must follow: (1) Have the carpet swept clean before washing. (2) When scrubbing with the soap mixture do not press down too hard on the brush; scrub lightly and quickly over the surface. (3) Do not scrub too large a place at once. (4) Wring the rinse cloth out almost dry and wipe off all the soap. (5) Dry thoroughly with a clean, dry cloth. When the carpet is all washed, open the windows and it will be perfectly dry in two or three hours. If you follow these directions carefully, your cleaning will be a great success. When you have finished, you will find that the carpet has been wet on the surface only.

Wall Paper.—Grease spots on wall paper can be removed by placing a piece of blotting paper or other porous paper over the spot, and passing a hot iron over it. When the grease comes up through the paper, move it so that a clean part covers the spot, and repeat the process until the spot is removed.

The Hands.—At this time of the year, when there is so much cleaning and preserving to do, it is almost impossible to prevent one's hands from getting stained, and if you do your own housework your hands are apt to get grimy very often. Nothing looks worse than grimy hands, and nothing feels worse than to shake hands with a person whose hand is hard and rough, when there is no reason for its being so. Of course, some people are not blessed with a naturally soft skin, and in their case hard hands are excusable, but rough and grimy ones—never. Mix together, in a bowl large enough to wash the hands in, one cup of yellow cornmeal and one-half cup of vinegar. Put your hands into it and wash and rub them until they are clean. You will be surprised to find how completely this will remove all grime and stains of any kind. After your hands are clean, wash them in warm water and you will find that they are not only clean and white, but soft and smooth to the touch.

Choked Pipes.—Drain pipes, etc., that have become choked with grease or soap, can be cleaned by sprinkling a little lye down the drain and then pouring in a quantity of boiling water. Almost any pipe can be cleaned in this way, unless it is clogged with something besides grease and soap. After the operation, it is advisable, if the pipe is of lead, to pour a little ammonia into it; this prevents the lye from eating the lead, which it would otherwise do, and thus counteracts any possible harmful effect.

THE DIESEL MOTOR.

THE Diesel motor may properly be called a triumph of the theorist. Mr. Rudolph Diesel, its inventor, is a thorough student of thermodynamics, as the study of the transformation of heat into work is called,

Fig. 1.

and is therefore specially fitted for the study of a problem relating to an improvement in heat motors. How well he has succeeded, the reader may judge after reading the description of the motor. The first experiments were begun in 1893, and after more than four years of careful work a mechanism was devised which reduced the theoretical engine to a practical one.

In order that the reader may fully understand this motor, a brief description of the theory upon which its operation is based will first be given. Fig. 1 is a theoretical diagram of the engine, which is supposed to operate as follows: During the first forward stroke of the piston, air at atmospheric pressure is drawn into the cylinder. The air is compressed on the return stroke of the piston without gaining or losing heat, and the pressure rises along the line marked P_1, P_2. The air is compressed until its volume is exceedingly small, its pressure being thereby raised to about 600 pounds per square inch, and its temperature increased to about 1,200 degrees Fahrenheit. When the piston has reached the extreme end of its stroke, the fuel—gas or petroleum—is admitted, and, because of the high temperature of the air, it takes fire as it enters, keeping the temperature up to that at P_2; the resulting expansion $P_2 P_3$ is made while the air is at a constant temperature. At P_3 the fuel is cut off and the temperature falls, but the amount of heat in the air is neither increased nor decreased, and the pressure continues falling along another curve $P_3 P_4$, similar to the compression curve $P_1 P_2$, until the end of the stroke is reached. Those of our readers who are familiar with thermodynamic terms will find this diagram an interesting study.

Practically the same series of operations takes place in the actual engine.

The general appearance of a 20-horsepower Diesel motor is shown in Fig. 2. The mechanism of the motor is shown in Figs. 3, 4, and 5. Fig. 3 is a side elevation of the engine, while Fig. 4 is a vertical section through the line *1–2*, Fig. 3. Fig. 4 also shows a plan of the bedplate, the pillow-block and the crank-shaft. Fig. 5 is a section at right angles to that in Fig. 4. Each part of the engine is designated by the same letter in each figure. Some of the minor details are omitted.

Fig. 2.

Referring to the figure, *A* is the cylinder,

B the piston, and *C* the compression space, which, it will be noted, is very small. The compression space is from 6 to 7 per cent. of the volume behind the piston when the piston is at the extreme lower end of the stroke, or about 7 to 8 per cent. of the volume swept over by the piston during one complete stroke.

The piston, it will be seen, is not of the trunk type so frequently encountered in gas-engine practice, but has a piston rod *D*, which necessitates the use of a crosshead *k*, so as to keep the motion of the rod in a

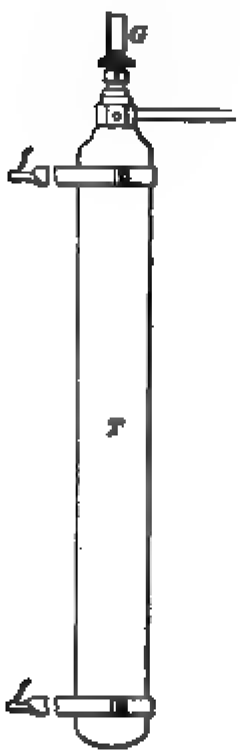
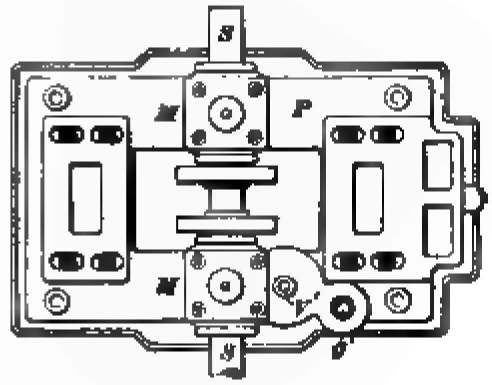


FIG. 3.

straight line. Motion is transmitted to the crank-shaft *S* by means of the connecting-rod *N* and the crankpin *U*. The water-jacket surrounds the cylinder, as shown at *J*, and water is also passed about the valves through the space *J'* in the cylinder head.

The air pressure required for starting, and for injection of liquid fuel, when such is used, is supplied by the pump *p*. This pump is operated, by the system of levers *x*, *y*, and *z*, from the connecting-rod *N*, the pump having a stroke equal to one-half that of the piston. The pump cylinder is water-jacketed, as shown at *j*, *j* The compressed air is stored in the starting tank *T*, at a pressure of about 100 pounds above the maximum pressure obtained after compression. In order that the pressure may be kept at the proper point, the suction pipe of the air pump is controlled by an automatic valve, which contracts the opening when the pressure rises in the tank *T*.

A small oil pump, not shown in the figure, supplies the fuel, as it is needed, to the fuel



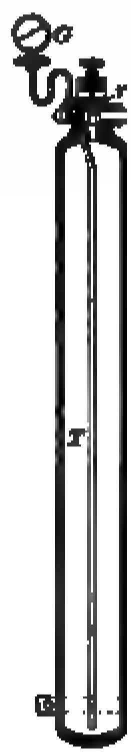


FIG. 4.

valve *m*. The oil enters the fuel valve through the small pipe at *o* and falls to the bottom of the valve compartment *o'*. When the piston reaches the end of its compression stroke, the fuel valve *m* opens and the fuel in *o* is blown into the compression space *C*, where it is ignited by the hot air in *C*. The amount of fuel varies according to the requirements of the engine, and is regulated by the governor *g*. The governor controls

the fuel pump by means of the lever l, and when the engine is running light it requires but a small amount of fuel. A portion of the oil is allowed to return to the tank through a by-pass valve.

The exhaust valve c, air valve d, and fuel valve m are all of the poppet type, operating by means of cams from the valve shaft V and a system of levers, as shown at h (Fig. 4). The valve shaft V is horizontal, and is driven from a vertical shaft V' by means of bevel gears. V' is also driven from the crank-shaft S by means of a pair of bevel gears, the gear on V' making but one revolution to two revolutions of the crank-shaft. The bevel gears, by which the horizontal shaft V is driven from V', have the same number of teeth; hence, both V and V' revolve at the same speed, and V makes one revolution to two revolutions of the crank-shaft.

Fig. 5.

When the engine is started, the operation is as follows: The fuel pump is disconnected from the engine and attached to the hand lever L. The flywheel is then turned by means of a bar, supplied for that purpose, until the crank is upon the upper center, or in the position shown in Fig. 4. The tank valve r is then opened, admitting air to the starting valve s. Valve s is thrown open by means of the starting lever H, admitting air from T into the compression space. The flywheel is then turned by means of the bar until the crankpin is far enough from the center to permit the air pressure from T to start the engine. At 30 per cent. of the down stroke, the starting valve s is closed, and the admitted air expands until the end of the stroke. During the next upstroke of the piston, exhaust takes place; and, just before the piston reaches the top of the stroke, the starting cam is thrown out of gear, the fuel cam put into gear automatically by a screw spring not shown in the figures, and the engine takes up its regular process as follows: (1) Downstroke: suction of air; upstroke: compression of air. (2) Downstroke: injection of oil, combustion to 10 per cent. of the stroke, and expansion of the burned gases; upstroke: exhaust.

The cylinder A is bolted to the engine frame O, and O is in turn bolted to the bed P. Catch basins for the oil are placed below the crosshead at b, and at the end of the piston travel at b'.

The pressure within the starting tank is shown on the gauge G. The air enters the cylinder at R, and the exhaust gases escape at E. The tank T is fastened to the wall of the engine room by means of the brackets f. In order to oil the piston regularly, the lever arm y has another arm x' attached to it which drives the oiling device by means of the levers y' and z'. The arm z' carries a pawl, which engages a ratchet v. The ratchet v is fastened to the shaft v', which carries a worm, engaging the worm-wheel u. The worm-wheel u is threaded, making it a nut which turns on the threaded plunger u'. The plunger u' sits on top of the oil in the cylinder q. Just as the engine piston reaches the lower end of its stroke, the pawl engages the ratchet, forcing a very small quantity of oil just below the top piston ring, thus effectually oiling the piston at a point from which the oil will be thoroughly distributed.

	Full Load.				Half Load.			
	Absolute.	Per Cent.	Absolute.	Per Cent.	Absolute.	Per Cent.	Absolute.	Per Cent.
Available heat (in calories)	50,213	100	43,273	100	27,148	100	27,760	100
Equivalent in indicated work	16,913	33.7	15,028	34.7	10,552	38.9	10,520	37.9
Transmitted to cooling water	19,580	39.0	17,450	40.3	12,250	45.1	12,030	43.3
Remainder	13,720	27.3	10,795	25.0	5,346	16.0	5,210	18.8
Equivalent in effective work	12,653	25.2	11,348	26.2	6,100	22.5	6,266	22.6

Mr. Diesel's theoretical work has been thoroughly investigated and endorsed by such prominent scientists as Prof. Zeuner, Lord Kelvin, Prof. Schroeter, Prof. Denton, Prof. Thurston, and others.

The motor, however, speaks for itself in the practical results already obtained, as shown by the accompanying table.

These results are the more astonishing when compared with the equivalent in effective work obtained with other motors. For example, the very best steam engines give but little better than 13 per cent. of the total available heat in effective work; and the total efficiency of the gas engine employing the Beaŭ de Rochas cycle, while better than the steam engine, scarcely ever reaches 18 per cent.

The combustion of the fuel in the Diesel motor is practically perfect. The exhaust of one of these engines discharging within a few inches of a wall of white enameled brick left no perceptible stain after a year of steady operation. Careful chemical analysis of the exhaust gases fails to show more than a mere trace of unconsumed fuel.

The engines are now being built by several European firms under the Diesel patents, and several American manufacturers are arranging to take the matter up, at least one American firm having already started their manufacture.

The policy of the owners of this patent is a most generous one. Unlike the Corliss engine when first introduced, the rights of manufacture are *not* to be the exclusive property of one firm, but the patent rights are evenly distributed, in order to encourage competition and to insure the rapid introduction of the motor.

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The Dixon Crucible Company, of Jersey City, N. J., has published a little pamphlet entitled "Helps in Brazing." It treats incidentally of brazing graphite, the application of which to bicycle tubes prevents the adherance of the spelter, and so effects a saving in labor by making unnecessary the filing which is otherwise needful. The pamphlet, however, treats especially of the process of brazing by the dipping method, or "liquid brazing," as it is called. The brazing crucible is described, together with instruction and caution in regard to its use. Instructions are given how to build and set the necessary furnace, time required for brazing, etc., etc. In regard to the economy of liquid brazing as against the old-time fire brazing, the following is quoted from a well known bicycle manufacturer: "We have been using the process of liquid brazing all this season, but at first found some difficulty in keeping the spelter at the proper temperature. We built several furnaces before we succeeded in getting one entirely successful. The one we have now in operation enables us to do as much work with one man and a boy as we were able to do before with five to seven men, and the results are much more satisfactory. We figure that we effect a saving of $20 per day, every day we run the new furnace. Besides requiring fewer workmen, we use only about 125 pounds of hard coal in a day's run, which is quite a contrast to the expense we were under with the old gas furnace, when our gas bills amounted to $250 per month. With the new process one man and a boy can turn out seventy-five machines in a run of seven hours." The pamphlet is of interest to all manufacturers and others who do brazing. It is sent free of charge.

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James L. Robertson & Sons, 204 Fulton St., New York, inform us that the demand for Eureka packing is still increasing, and that they have recently added to their numerous list of customers many large manufacturing concerns. Their sales for August amounted to over 6 tons, which went to all parts of the globe. The excellent reputation that Eureka packing has gained rests upon its uniformity of quality, and the high grade of materials that are used in its manufacture. The makers are always glad to send samples and trial lots to interested parties, free of charge.

CATALOGUE REVIEWS.

The Armstrong Manufacturing Company, Bridgeport, Conn., issue for 1898 a 54-page catalogue and price list of their well known stocks and dies, and other tools for the use of water, gas, and steam fitters. Size of book, 7″ × 5″. Particular attention is called to a line of newly designed machines for threading and cutting off pipe. These machines, which are of excellent design, are made in five sizes; the smallest one threads and cuts off pipe from 1 to 3 inches inclusive, while the largest size deals with from 1- to 6-inch pipe. An excellent feature of these machines is that all the driving gears are enclosed in an oil chamber, by which means they are not only thoroughly lubricated but are kept free from dirt and chips.

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The Seneca Falls Manufacturing Company, Seneca Falls, N. Y., publish two

catalogues, numbered respectively 16A and 16B. The first of these is devoted to their foot- and hand-power wood-working machinery, and embraces an exceptionally full line of machines specially designed for the use of carpenters, builders, cabinetmakers, patternmakers, etc., such as scroll saws, combination saws, molders, and foot lathes. No. 16B is entirely devoted to foot-power lathes and accessories. The lathes and other foot-power machinery manufactured by this concern are fitted with a patent "walking-motion" foot power, which is claimed to be an improvement on anything heretofore brought out; the levers are so arranged as to give great freedom to the operator, and can be worked with either foot, while standing, or with both feet while sitting. A special feature of the lathes is an end-thrust ball-bearing spindle, whereby the friction during drilling is reduced.

BOOK REVIEWS.

HAND BOOK OF CORLISS STEAM ENGINES. Cloth. Size 7″ × 4½″. Seventy Illustrations. By F. W. Shillitto, Jr. Published by The American Industrial Publishing Co., Bridgeport, Conn. Price, $1.00.

This little book is written for the purpose of giving the practical information most needed by the working engineer who must superintend the erection of a Corliss engine, and make correct adjustments of its valves and other working parts. The section on erecting Corliss engines gives excellent general directions for the construction of foundations, which apply equally well to foundations for engines other than the Corliss. The directions for setting up and lining apply particularly to the regulation type of Corliss engine, and are clear and practical. The section on adjusting explains briefly the general features of the Corliss valve and gear, and its relation to the ordinary slide valve. It also points out the principal differences between the various types of Corliss gear in common use, and shows how the setting is modified to suit these different types. The chapter on the use of the indicator in valve setting is, perhaps, a little too brief. Although, as the author states in his preface, there are many excellent treatises on the use of the indicator now to be had, it would have made this book more complete, and added to its value as a practical engineer's handbook, if the special application of the indicator to Corliss engine practice had been made more comprehensive. Some of the leading types of Corliss engines now on the market are illustrated and briefly described. The book will be found particularly useful to young engineers who wish to become thoroughly familiar with the Corliss valve gear and its adjustments.

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PRACTICAL SHOP TALKS. By Fred H. Colvin. Cloth, size 6″ × 3½″, 144 pages. Published by The Locomotive Engineering Co., 256 Broadway, New York. Price 50 cts.

In this little book, "A collection of letters on shop subjects which show by actual examples some of the existing methods of shop management and practice," Mr. Colvin, whose experience makes him familiar with many methods of shop management and—incidentally—*mis*management, writes as one who would say to employer and employee alike, "Why don't you open your eyes and see the many little foolishnesses that exist and thrive in your shop? Why don't you look to it that Mr. Theory and Mr. Practice work together in a friendly manner, and that Mr. Draftsman is respected as he should be and paid as he should be? Why don't you say to Mr. Ignorance whom in your *own* ignorance you clothed with authority some years ago, 'Get out of this! I have found you out; my foreman must know more than simply "Where things are kept" and "How we always *have* done it." He must be an energetic, practical man—of varied experience, and of some originality.'" In a delightful conversational style, many amusing dialogues are introduced, in which the author shows that he knows a good deal about machine-shop practice and of human nature too. He depicts the disasters caused by the office interfering with the shop; shows how foolish it is to do a thing in a certain way simply because it always *has* been done that way; points out the vast importance of shop system, of building machines in lots, of paying good men well and of employing none but good men; and so on. "Practical Shop Talks" originally appeared in "Machinery" as "'Notes from Notown' by Ichabod Podunk." Those who then had the pleasure of reading the letters will no doubt be glad to possess them bound in book form.

NOTE.—In HOME STUDY MAGAZINE, July, 1898, Answers to Inquiries, No. 266 (*c*), which read "Can Mushet's steel be annealed?" we answered "No." This was an error. We are indebted to B. M Jones & Co., Boston, for the following information There is no steel made that cannot be annealed. The following are our directions for treating Mushet's special steel, to make it adapted for milling cutters, taps and dies, reamers, rose bits, countersunk drills, and twist drills: After the steel is forged, heat it up thoroughly to a light yellow (short of burning), and bury it in hot ashes from the smithy fire, or in lime, and cover over with fine ashes or sawdust, so as to exclude the air thoroughly till perfectly cold. The steel will then be annealed for turning, filing, etc., but, if it is found to be hard below the surface, when cut into for working, it may be necessary to anneal again before finishing.

To Harden it Again.—This may be done with the entire piece, or in any one part of the piece, leaving the rest annealed, viz.:

For Hardening Milling Cutters.—Heat up to a bright yellow (short of burning). If the "cutters" are thin, cool in the air, suspended by a wire. If they are thick, they should be cooled quicker by holding them over a strong cold-air blast pipe and kept slowly revolving in the blast till cool.

For Hardening Taps and Dies.—Heat a tap quickly upon the threads (which always catch the heat first) and cover quickly with the cold-air blast, afterwards heat the "square" at the shank of the tap to a good red, so as to harden it sufficiently for use. This same treatment will apply to reamers. For long taps and reamers there is not the trouble of "twisting" that there is in water-hardening steel.

For Hardening Screw Dies.—Heat them quickly on the thread, and cool them in the cold-air blast. This will also indicate the treatment for the hardening of other articles.

Local Hardening.—Take care to cover the parts that are intended to be left annealed with clay, or any "composition," say asbestos, and heat the exposed part, which is intended to be hard, and cool quickly in the cold-air blast. For hot punching and cold punching, the steel should be annealed and hardened at the point. For shear blades for cutting hot iron, the steel should be annealed and hardened on edge. For wearing parts of heavy machinery, the steel should be annealed and hardened.

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(443) In your September issue I note Mr Thomson's article entitled "Greenhouse Heating." I have a conservatory on the northwest side of my house that gets very little sunlight. Would a system such as you describe be suitable for my place, and could the conservatory be used for raising or keeping anything besides green plants during the cold winter months?
E. A. R., Baltimore, Md.

ANS.—A hot-water heating system like that described in our September issue is suitable for any small greenhouse. The greenhouse, or conservatory, need not necessarily be a "lean-to," and it does not require to be close to the building. You can easily heat a small greenhouse with such a system, even although it is as far as 100 feet from the building in which the boiler is located, provided, of course, that the boiler is a few feet lower than the greenhouse heating coils. It is a pity that your conservatory does not face the south, because then you could have the full value of the sun's rays, and the plants would thrive so much better than they will in a shaded greenhouse. Nearly all ordinary plants can live in your greenhouse during winter, if you furnish proper heat and ventilation, but they will not bloom so well or be so healthy as those that have plenty of sunshine every day.

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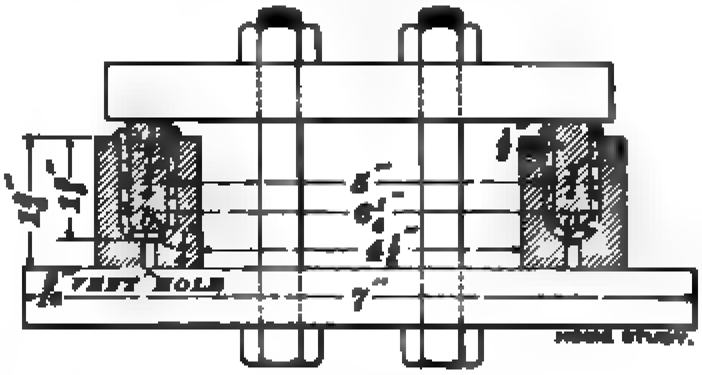
(444) Kindly explain how U leather packings are made, and give sizes of mold and follower for a 5-inch ram, 6¼-inch recess, 1¼ inches deep. Can such a packing be pressed in one mould?
H. W. S., Pittsburg, Pa.

ANS.—A very simple method of making such a U leather packing ring as you describe is shown in the



figure, which has all the dimensions required. The section of the packing may be circular at the bottom, as shown at *a*, or it may be flat, with rounded corners, as at *b*, in any case it should be made to fit the recess as neatly as possible. Take a ring of leather of sufficient size to make the packing as shown, using close-grained leather of uniform thickness, and soak it in water until it is perfectly pliable. Press it carefully and evenly into the mold and let it remain for about 12 hours, then take it out and let it dry, after which it may be trimmed, when it will be ready for use.

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(445) (*a*) In regard to the gas-engine igniter described in HOME STUDY MAGAZINE, March, 1898, Fig. 4, I would like to know if this igniter is as reliable as the other forms described. (*b*) What should the length of the spark be? (*c*) Please give the dimensions of the coil, also, the size of wire and number of layers in each of the primary and secondary windings. (*d*) How can I make the coil waterproof?
L. J., Jamestown, N. Y.

ANS.—(*a*) The igniter referred to is used on the Priestman oil engine, but the one shown in Fig. 5 in

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see contents page

the article referred to is in more general use by gas-engine makers. (*b*) A ⅛-inch spark would probably answer your purpose, but a ¼-inch spark would be more certain to ignite every time. (*c*) For a ¼-inch spark coil make a core of No. 16 annealed-iron wire. The core should be 4 inches long and ½ inch in diameter. Cover this core with paraffined paper $\frac{1}{16}$ inch thick, and wind on the primary coil, allowing $\frac{3}{16}$ inch of the core to protrude from each end of the winding. The primary should consist of three layers of No. 16 single cotton-covered magnet wire, and each layer should be shellaced. Cover the primary with paraffined paper $\frac{1}{16}$ inch thick, and wind on 88 ounces of No. 34 single cotton-covered magnet wire, run through paraffin while winding. (*d*) Immerse the entire coil in paraffin, and box it up, leaving only the terminals and the circuit-breaker outside the box.

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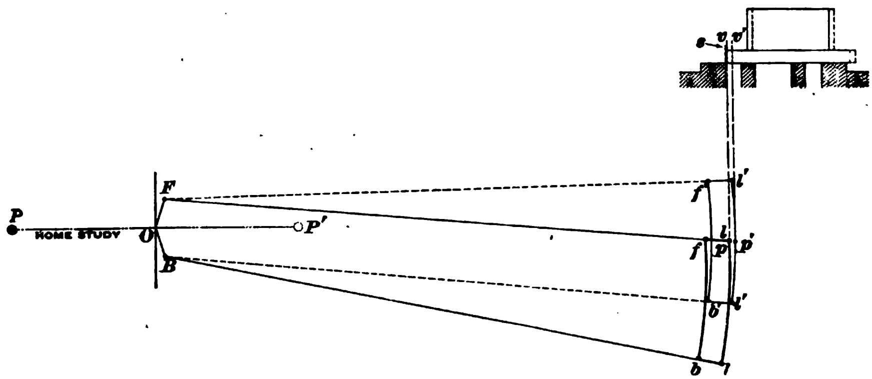
(446) (*a*) Two engineers were engaged in the discussion of the "lead" of a locomotive engine; *A* claimed that it was done by the blade of the eccentric, while *B* maintained that it was done by the eccentric itself; who was right? (*b*) If the lead is brought about by the eccentric alone, how is it that when you hook up the reverse lever, the lead is increased? (*c*) When an engine is working steam with dampers closed, will the tubes be affected so as to be likely to leak? An engineer I know claims that an engine working steam under the above conditions creates vacuum. Is this so? (*d*) How would you set a slip eccentric of a Vauclain compound? Has this engine an intercepting valve? (*e*) Our master mechanic relates an instance where an engineer on a "freight" was to meet a "passenger" half way on a 9-mile down grade, and remembered it when but two miles from the meeting place. When he attempted to apply the brakes, he found the pump was stopped; knowing it was useless to call the brakeman's attention, he worked both injectors, filled the boiler, worked engine in back motion and thereby came to time. Is any such thing possible?

R. F., New Orleans, La.

ANS.—(*a*) *B* was right. (*b*) It is quite true that altering the length of the eccentric blade or rod will increase the lead, but only *at one end* of the stroke; it will decrease it at the other. Moving the eccentric around on the axle gives lead at both ends, or decreases it if moved around in the other direction. In the accompanying sketch, it will be seen how the lead increases toward mid-gear. To simplify matters, the rocker has been omitted and also the valve rod and stem, making the valve appear to be directly over the link. *P* shows the crankpin on the back center, *F* and *B* representing the centers of the fore and back eccentrics, respectively. The dark outline *f b l l* represents the link (at least enough of it to answer our purpose), *f* and *b* being the centers of fore and back eccentric rod pins, and *l l* the link arc (the center line of the curved slot in which the link block slides). *p* is the center of the link block (and, therefore, of the rocker pin when there is one), and as this governs the position of the valve, the vertical line *p v* shows the position of the steam edge *v* of the valve when the crank is on the back center, the lead being as shown. Now lift the link into mid-gear. The new positions of *f*, *b*, *l*, and *p* are *f′*, *b′*, *l′*, and *p′*. The vertical line *p′ v′* determines the new position of the steam edge *v′* of the valve. Thus, the lead has increased from *s v* to *s v′*. This increase is, on the average, about ¼ inch; that is, an engine having ⅛-inch lead in full gear will probably have about ⅜ inch in mid-gear. The actual variation depends on the length of eccentric rods, distance between eccentric pins in the link, etc. If the rods were *crossed*, that is, if *F* were connected to *b* and *B* to *f*, the lead would decrease as the link was lifted into mid-gear. It is the practice now to adjust the lead for the "running position" (this is generally from 25% to 30% in passenger engines under normal conditions). A full gear lead of ⅛ inch would give more lead in this position than is considered desirable; $\frac{3}{16}$ inch is the amount usually chosen. To obtain not more than this amount will necessitate the valve being set from $\frac{1}{16}$ inch to ⅛ inch "blind" in full gear. If the engine has rockers (as all American locomotives have) the crankpin will be on front center at *P′*, with the eccentrics in their present position, each being 90° − angle of advance *behind* its respective crank, instead of 90° + angle of advance ahead of it, as in sketch. This is true, roughly speaking; as a matter of detail, it would only be the case if the center line of motion coincided with the axis of cylinder, a state of affairs very seldom occurring in this country. (*c*) There is always a certain amount of vacuum produced in the smokebox, owing to the exhaust. To fill the space left vacant by the withdrawal of the air, induced by the blast, other air finds its way in, if possible. If the smokebox door is perfectly air tight, as it should be, air to supply this loss can only come in from the firebox, either through the dampers or else through the firehole door. The less the door is kept open the better, as this is a fruitful cause of leaky tubes. If the door and dampers are shut tight, the vacuum in the smokebox will become more perfect. The amount of vacuum actually obtained varies with the boiler pressure, cut-off, amount of throttling, and the size of blast nozzle and chimney. As regards the tubes leaking, the most frequent cause is, as before remarked, the opening of the firedoor, thus letting cold air strike the back tube-plate. This is particularly the case when no deflector or baffle plate



is used inside the firehole opening. Another injurious practice is to turn the feed on when drifting. If this is necessary, the blower should be started, so as to have a good draft of flame through the tubes, and thus counteract the tendency of the feed to lower the temperature. (*d*) Set it the same as on any other engine. Suppose it is the fore gear eccentric that has slipped. Put the engine on the front center and set it in full back gear. Then mark the valve stem with a tram or else scribe the stem close up against the stuffingbox. Then put the lever right over in the fore gear and turn the eccentric around on the axle until the stem comes into the same position as before; get your fireman or one of the brakemen to watch the stem and tell you when the above position is reached. Then tighten up the eccentric. This setting will suffice very well to carry you home. Unlike the Brooks, Schenectady, Pittsburg, and other compounds, the Vauclain has neither receiver nor intercepting valve. (*e*) Yes. The idea is, of course, to get water into the cylinder and thus gradually arrest the motion of the engine. Better knock the cylinder heads off than have a collision. We, however, would prefer to simply reverse the engine and give her steam, gently at first, using sand at discretion. Why couldn't the engineer in question apply the brakes and stop, even if his pump *had* failed? If his auxiliary reservoirs were charged, the brakes could have been applied, and if the main reservoir were also charged, the brakes could have been released; if, however, there was not enough air in the main reservoir, he would have had to pump up to get the brakes off. The question, however, was one of simply stopping the train.

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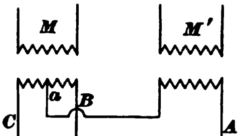
(447) Can a two-phase motor be run with a three-phase current? I am looking after motors in a mine, and wish to know if there is any way to change a three-phase current so as to use it for a two-phase machine. W. L., Eslado Elgado, Mex.

ANS.—Connect the primaries of two transformers to the three-phase circuit, as shown in the figure. The connection *a* should be made just half way between the terminals *B* and *C*, or at the middle of the primary winding. This can be accomplished by baring the insulation and soldering on a connection. The three conductors of the three-phase circuit should be connected to *A*, *B*, and *C*, and the two-phase motor by means of four conductors to the secondaries *M*, *M'*.



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(448) (*a*) On page 63 of "Mechanics' Pocket Memoranda," the formula for the square of the radius of gyration is given as $G^2 = \frac{I}{A}$, or moment of inertia divided by area of section. On page 45, Table V gives, for a solid rectangle, $G^2 = \frac{b^2}{12}$, while according to the above formula it should be $\frac{b\,d^3}{12} \div b\,d = \frac{d^2}{12}$. A similar discrepancy occurs in the case of the hollow rectangle, of the solid, of the hollow ellipse, and of the I beam. If these are not simply typographical errors, please give reason why, in the cases mentioned. I for value of G^2 is taken for an axis perpendicular to that considered in column 1 of Table V. (*b*) What is the formula for G^2 for a hollow cylinder revolving round its axis? (*c*) In "Electrical World" of August 13, 1898, in an article on Crocker-Wheeler direct-connected dynamos, page 168, there is the following statement, referring to the design of a flywheel for a certain combination set: "From the curve we learn that the fluctuation of energy is 38 per cent. per stroke; 38 per cent. of 48,000 (foot-pounds delivered per stroke of the engine) is 17,900 foot-pounds, which is the energy stored in the wheel per stroke. We must find the flywheel that will absorb or deliver this energy without changing speed more than .4 of 1 per cent. The energy stored in a revolving body being equal to one-half its mass, multiplied by the square of its angular velocity times the square of its radius of gyration, we readily find that the above condition is fulfilled by a wheel 16 feet in diameter and weighing 22,800 pounds." Kindly explain how this size and weight are obtained.

S. S., Schenectady, N. Y.

ANS.—(*a*) The discrepancies mentioned are typographical errors, and have been corrected in the last edition of the "Mechanics' Pocket Memoranda." (*b*) $G^2 = \frac{1}{2}(r_1^2 + r_2^2) = \frac{1}{8}(d_1^2 + d_2^2)$ where d_1 is the outer, and d_2 the inner, diameter. (*c*) Referring to the article in question, the speed is 100 revolutions per minute. Denoting the angular velocity by w, this speed gives $w = 2\pi \times \frac{100}{60} = 10.472$. To store the required energy, the angular velocity must vary from a minimum w_2 to a maximum w_1, the increase of energy being, therefore,

$$\frac{W G^2}{2g}(w_1^2 - w_2^2) = \frac{W G^2}{g}\left(\frac{w_1^2 - w_2^2}{2}\right),$$

where G is the radius of gyration. Now, the average angular velocity is $\frac{w_1 + w_2}{2} = 10.472$, and, from the statement of the problem, the variation in speed is .4 of 1 per cent., that is, $w_1 - w_2 = .004 \times \frac{w_1 + w_2}{2}$. Multiplying both sides of this last equation by $\frac{w_1 + w_2}{2}$,

$$\frac{w_1^2 - w_2^2}{2} = .004 \times \left(\frac{w_1 + w_2}{2}\right)^2 = .004 \times 10.472^2.$$

The increase of energy required is 17,900 ft.-lb. Hence,

$$\frac{W G^2}{g}\left(\frac{w_1^2 - w_2^2}{2}\right) = \frac{W G^2}{g} \times .004 \times 10.472^2 = 17{,}900,$$

or, $$W G^2 = \frac{17{,}900 \times 32.16}{.004 \times 10.472^2} = 1{,}312{,}400.$$

The radius of gyration G must be nearly equal to the radius of the wheel. If we assume $G^2 = .9\,R^2 = 9 \times 8^2 = 57.6$, $W = \frac{1{,}312{,}400}{57.6} = 22{,}800$ pounds, nearly.

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(449) (*a*) How is the low temperature that is required to liquefy air obtained? (*b*) Has air been solidified? (*c*) Since air is a mixture of oxygen and nitrogen, why are these gases not liquefied separately and then mixed to form liquid air? Would this method be simpler than the other? (*d*) How can ink stains be removed from the skin, from paper, from cloth, and from kid gloves, without injury? (*e*) What is the meaning of a chemical formula such as $MgNH_4HPO_4$? Can you tell me of any good book on the subject? (*f*) Can you mention any good book on artificial illumination?

J. W. S., New York, N. Y.

ANS.—(*a*) This question will be answered, more fully than the space here would admit, in an article on liquid air in a future number of this magazine. (*b*) Yes; in the form of a snowy mass. (*c*) No; because oxygen and nitrogen have to be first artificially produced, and consequently two gas-generating apparatus and two liquefying apparatus would be required. (*d*) Ink stains may be removed from the skin by wetting the skin with water and then rubbing the stains with a piece of citric acid; from paper, by touching the ink stain with a little hypochlorous acid and washing the wetted surface, by means of a sponge, with water. We don't care to give you a receipt for removing ink stains from cloth and kid gloves, as to do this considerable skill and experience is required, or you will destroy either the material or its color; better go to a reliable cleaning store. (*e*) A chemical formula shows the composition of a compound; the formula you mention shows the

chemist that the compound consists of 1 atom of *Mg* (magnesium), 1 molecule of NH_4 (ammonium), 1 atom of *H* (hydrogen), 1 atom of *P* (phosphorus), and 4 atoms of *O* (oxygen). A compound $MgNH_4HPO_4$ does not exist: probably you mean $MgNH_4PO_4$ (magnesium ammonium phosphate). We can recommend to you Wuertz's "Elements of Chemistry," and Fowne's "Elementary Chemistry." (*f*) "Electric Lighting," by F. B. Crocker, and "Gas Fitting and Lighting," by William Paul Gerhard. You can obtain all of these books from The Technical Supply Co., Scranton, Pa.

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(450) (*a*) If you were putting in an elliptic arch and wanted to lay each course of brick with the proper radius, where would you fasten your three different lines necessary to give the correct dimensions? (*b*) Where for a Gothic arch?

F. L. M., Washington, Iowa.

ANS.—(*a*) We presume you wish to know how to obtain the curve to which the centering is to be cut. The curvature of a true elliptic arch changes at each point, so that really there would be as many centers as there are stones or bricks in the ring. A fairly close approximation to an elliptic arch is the three-centered, or false elliptic arch, to which you no doubt refer in your question. There are several ways for constructing this curve, of which the method shown in the left half of Fig. 1 is probably the best. Lay out *a c* equal to the span of the arch, and *b o* equal to the rise. Draw *a a'* and *b a'* perpendicular to *a o* and *o b* respectively, also *o b'* equal to *o b*. Bisect *a a'* at *a''*; draw *a'' b* and *a' b'*, marking the point of intersection *d*. Bisect *d b* in *e* and erect *e f* perpendicular at this middle point. With *f*, where *e f* intersects *b o* produced, as a center, and *f b* as a radius, draw arc *b d h*, *f h* being parallel to *a o*; through *h* and *a* draw *h g*, cutting the arc *b d h* at *g*; draw *g f*, cutting *a o* at *j*; then draw arc *a g* with *j* as a center, completing the curve. The other half may be constructed similarly. The joints at any point are, of course, radial from the proper center. It is just as easy, however, to make the curve a true ellipse, as shown in the right half of Fig. 1. This may be constructed as follows: Draw arcs *c r* and *m b*, with the longer and shorter semi-axes as radii, respectively. Draw radii as *o i'*, etc.; from *i*, where *o i'* intersects the smaller circle, draw a line parallel to *o c*, and from *i'*, draw a line parallel to *q r*; the point *i''* of intersection of

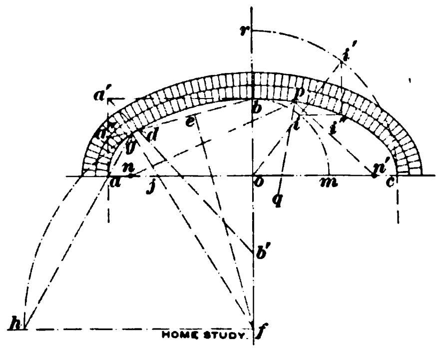

FIG. 1.

these lines is a point on the curve. Find a sufficient number of points in the same way, and draw the curve. The direction of the joints at any point may be found thus: Mark the foci *n* and *n'* by striking arcs from *b*, with *a o* as a radius. Let *p* be a point where the perpendicular to the curve is to be found. Draw *n p* and *n' p*; bisect the angle *n p n'*, as at *p q*; then *p q* is perpendicular to the curve at *p*. Any other normal may be found in the same way. (*b*) There are a great many arches of the Gothic or pointed type. As you mention no particular kind, we have shown, in Fig. 2, a four-centered arch. Let *a b* be the span, and *o c* the rise, in this case equal to *a o*. The lines *c k* and *c l* are to be the tangents to the

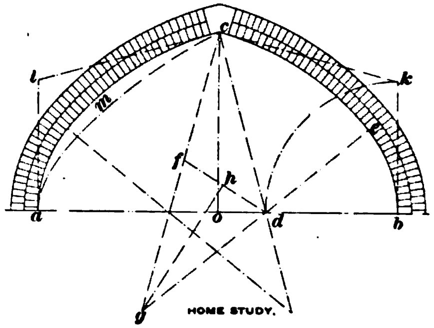

FIG. 2.

arcs at *c*, and make equal angles with *o c*; if the angle *o c l* is decreased it makes the arch more pointed at *c*, as shown by the dotted line *a m c*; if increased, it renders the arch flatter at the crown; in this case it is 75°. Draw *b k* parallel to *o c*, and cutting the tangent *c k* at *k*; draw *c g* perpendicular to *c k*; make *b d* and *c f* equal to *b k*, and draw *f d*; bisect it at the middle point *h*, and mark the point where the perpendicular *h g* cuts *c g*. Then *g* is the center for arc *c e*, and *d* for arc *e b*. The other half may be drawn in a similar manner.

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(451) Please explain to me how to splice a steel-wire rope. I am running an engine that pulls coal out of a slope, and there is 1,000 feet of rope on it. Whenever the rope breaks, I have to get some one else to splice it for me. That is why I ask the question. If you cannot answer it in your columns, can you tell me of any one in Lackawanna County who will be willing to explain it?

ENGINEER, Olyphant, Pa.

ANS.—The length of a splice depends upon the size of the rope. For a rope having a diameter not exceeding ¾ inch, the length of splice should be 20 feet; not exceeding 1¼ inches, 30 feet; above 1¼ inches, 40 feet. To splice a 1-inch rope, draw the ends past one another so that there is 30 feet of lap. Bind each rope tightly with a cord, slightly over 15 feet from its end, untwist each rope up to this cord, and cut out the hemp center from each rope to exactly 15 feet from the end. Now interlock these loose strands, after the manner of a person clasping his hands together, and draw the ropes into one another until the ends of the hemp centers meet. Unwrap some of the cords binding the ropes, and unlay one of the strands from this rope, at the same time carefully laying in its place the strand of the other rope, which naturally winds into place, replacing at once the binding cord. Bind another cord around each rope, exactly 15 feet from the center of the splice, and continue to unlay the strand to within 6 inches of this cord. Cut off the unlaid strand 12 inches from this binding cord. Lay in the other strand snugly, leaving now 6 inches of each strand as loose ends, to be secured later; and again bind another cord over the laid strand to keep it from unwinding. Return now to the center of the splice, and perform the same operation upon the other rope, unlaying from this second rope the strand next to the one we have just laid in on the first rope,

and winding carefully in its place the corresponding strand from the first rope, leaving finally two loose ends 6 inches long, as before, to be secured later. We have now disposed of two of the six strands of each rope; and, returning to the center of the splice, we repeat the operation of unlaying the next strand from the first rope, and laying in its place the corresponding strand from the second rope. But this time we bind a cord around each rope only 9 feet from the center of the splice, and unlay to within 6 inches of this cord, cutting the strands so as to leave two loose ends, as before, to be secured later. The same is done upon the second rope, leaving two loose ends there also, 9 feet from the center of the splice. The same operation is repeated finally upon the two remaining strands of each rope, only stopping and leaving the loose ends this time 3 feet upon each side of the center of the splice. The length of the splice is thus 30 feet, with loose ends every 6 feet. The space between the loose ends must always be determined by dividing the length of the splice by the number of strands less 1. Each of these loose ends must now be secured by fastening two clamps to the rope, one upon each side of the ends to be fastened, and about 18 inches apart. The two binding ropes at this point are then removed, and the rope untwisted by turning the clamps in opposite directions. The hemp center is cut out for a length of 12 inches, the loose ends laid in its place as snugly as possible, and the rope allowed to twist again to its place. Wooden mallets are used to smooth down any unevenness and cause the strands to assume their proper place.

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(452) Kindly give me instructions for making a pantograph. H. B., Montreal, Que.

ANS.—See HOME STUDY MAGAZINE, October, 1898, Answers to Inquiries, No. 389.

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(453) Please publish a full description of how to make an efficient fan motor, of the simplest construction, to be run by a battery.

G. W. S., Pitcairn, Pa.

ANS.—We cannot undertake to calculate windings for special machines for amateurs, as this involves considerable work, and is seldom justified. Castings, with full directions for winding, may be obtained from any of the following concerns: M. R. Rodrigues, 19 Whipple St., Brooklyn, N. Y.; Reading Electric Co., Reading, Pa.; Mianus Electric Co., Mianus, Conn.

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(454) (*a*) What is the meaning of "sea level" as used in reference to the height of a mountain? I cannot take the meaning given in the dictionary, because it says that, in some places, the level of the sea varies 60 feet, according to the state of the tide. (*b*) If a spherical cannon ball were to hitch itself to a pair of wings just as it left the mouth of the gun, and the wings had a tendency to lift the shot—like aeroplanes—would the shot go farther than without them, leaving out of consideration the weight of the wings? Or, if a flat, thin slate were thrown with a given force into the air, so as to float, as it were, its thin edge cleaving the air, and a spherical stone of the same weight were thrown in the same direction with the same force, would not the flat slate go farther than the spherical stone?

R. B. W., Amherst, N. J.

ANS.—(*a*) The sea level used as a datum in the U. S. Geodetic Surveys is an *average* sea level, and is determined for any point on the coast by means of a self-registering automatic gauge. Accurate determinations of the sea level require continuous observations for several years. An account of the method of making observations, and a description of the instruments employed, may be found in Appendix No. 8, U. S. Coast Survey Report for 1876. (*b*) The winged shot would go farther, and the flat disk would have a greater range than the spherical ball.

***

(455) Some time ago I saw a chain bicycle which the rider claimed was a multiple gear. The main sprocket was not much larger than the rear spocket, and yet he claimed that it was equivalent to a 72-inch gear of the ordinary kind. Can you explain?

M. A. G., Schenectady, N. Y.

ANS.—We do not know of any bicycle now on the market which is geared as you say; but, by means of a combination of toothed gears and chain, it is possible to obtain the design mentioned. Some years ago an English inventor patented a combination of the kind in which it was possible, while riding, to change the ratio of the bicycle gear; the inventor intended that the rider when on a level road should use the high gear, and when riding up a steep hill change to the low gear, by which means increased leverage would be obtained. The arrangement, as first produced, varied the gear from about 72-inch to 40-inch. Owing to mechanical defects the arrangement never became popular, but we have no information as to the precise arrangement of the parts.

***

(456) What are the materials, and the proportions of them, used in making gunpowder? Please give me a formula for making red, green, and blue powder for fireworks?

G. W. G., New York, N. Y.

ANS.—The ingredients are the same in the various kinds of gunpowder, but differ in their proportions according to the use for which the powder is intended. The usual proportions are as follows, *N* denoting nitrogen, *ch* charcoal, and *S* sulphur:

Military purposes, 76 *N*; 14 *ch*; 10 *S*.
Sporting purposes, 78 *N*; 12 *ch*; 10 *S*.
Blasting purposes, 62 *N*; 18 *ch*; 20 *S*.

FOR FIREWORKS.

Red.	Nitrate of strontia	25 oz.
	Chlorate of potash	15 oz.
	Sulphur	13 oz.
	Black sulphide of antimony	4 oz.
	Mastic	1 oz.
Green.	Chloride of baryta	2 oz.
	Nitrate of baryta	3 oz.
	Sulphur	1 oz.
Blue.	Chlorate of potash	3 oz.
	Sulphur	1 oz.
	Ammonia-sulphate of copper	1 oz.

The above fires are for use in tubes such as are carried in parades, etc. Where the powders are to be burned in the open, the make-up is rather different:

Red.	Niter	5 oz.
	Sulphur	6 oz.
	Nitrate of strontia	20 oz.
	Lampblack	1 oz.
Green.	Niter	24 oz.
	Sulphur	16 oz.
	Nitrate of baryta	48 oz.
	Lampblack	1 oz.
Blue.	Niter	8 oz.
	Sulphur	2 oz.
	Sulphate of copper	4 oz.

***

(457) Kindly explain the theory of the shifting of the brushes on the Wood arc dynamo.

E. E. T., Joliet, Ill.

ANS.—In the Wood arc dynamo the regulator is operated by a belt from the shaft which drives one friction cone pulley in one direction, and another beside it, on the same spindle, in the opposite direction. The friction wheel, which actuates the gearwheels connected with the rocker-arm, is moved into contact with either of the cones by an arm operated

by a solenoid. The current energizing this arm varies as the current strength from the machine varies. For instance, if a few lamps are cut out, the current will rise in strength and operate the plunger of the solenoid. This throws the friction wheel, of the train of gears operating the rocker arm, into contact with one of the cones, thus turning the brushes back through an angle sufficient to cut down the voltage to a point at which the current strength is that at which the machine is designed to operate. Take the opposite case. If more lamps are thrown on the circuit, the voltage at which the machine is operating is insufficient to maintain the requisite current strength through the line, and the current will fall in strength, thus allowing the plunger in the solenoid to drop. The friction wheel is then thrown into contact with the other cone, bringing the rocker-arm ahead to such a position that the current strength is raised to its proper value. The regulator on the latest Wood machines is very efficient and rapid in its action.

***

(458) I wish to make a sheet-iron sphere, 30 inches in diameter, in 22 equal sections. Kindly give the development of one of the sections.

T. K., Whistler, Ala.

ANS.—It is undesirable to make a sphere of 22 equal sections, because such sections have very slender end joints, and these joints all meet, as illustrated in Fig. 1. Lap joints would produce a lump, and cannot therefore be used. If such sections are wanted, their points should be cut off and a circle added in their place, as indicated. The best way to construct a 30-inch sphere is to make it of 20 equilateral triangles, and form each triangle before putting them together. Butt joints should be used, and a strip lapped on the inside. All the joints may be riveted, except the last three; these will have to be screwed. The construction for the sections shown in Fig. 1 is as follows. Deduct the thickness of the metal from the diameter, and multiply by 3.1416. In this case

FIG. 1

we will assume the thickness to be $\frac{1}{32}$ inch. We then have $\left(30 - \frac{1}{32}\right) \times 3.1416 = (30 \times 3.1416) - \frac{3.1416}{32} = 94.248$ in. $- 0.1$ in. $= 94.148$ inches. We have taken $\frac{3.1416}{32}$ as 0.1, which is near enough. In forming the pieces they will stretch more or less, probably about one-hundredth of their size in this case; therefore, this much should be deducted for the pattern of the parts. Thus, $\frac{94.148}{100} = .94148$, and $94.148 - .94148 = 93.20652$, or practically 93.21 inches. Dividing this by 22, we get 4.24 very nearly, or $4\frac{1}{4}$ inches, scant.

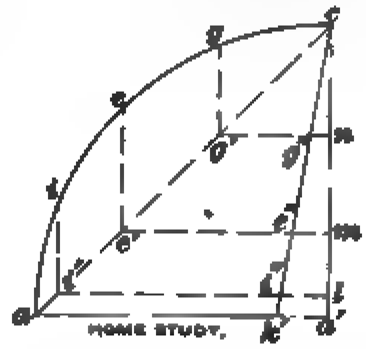

FIG. 2.

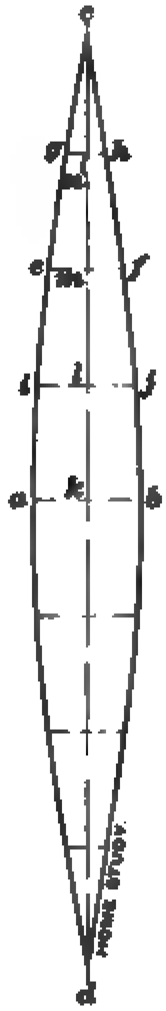

FIG. 3.

This is the width of each section at $a\,b$, Fig. 3, and the length $c\,d$ is one-half of $93.21 = 46.605$, or $46\frac{5}{8}$ inches, scant. The widths at other places, as $e\,f$, etc., are found by drawing a quadrant $a\,c$, Fig. 2, with a radius $a\,a'$ equal to the radius of a circle whose circumference is 93.21 inches long, that is, $\frac{93.21}{3.1416} \times 2 =$ about $14\frac{13}{16}$ inches $= a\,a'$. Divide the arc $a\,c$ into equal parts, corresponding to $a\,i$, $i\,e$, etc., as shown. The distances of i, e, etc. from $c\,a'$, are the radii of circles of which $\frac{1}{22}$ is equal to $i\,j$, $e\,f$, etc., respectively. Graphically, the widths $i\,j$, etc. are easily obtained by making $a'\,k'$, Fig. 2, equal to $a\,k$ of Fig. 3, and drawing $a\,c$ and $k'\,c$, Fig. 2. By drawing a parallel to $a'\,c$, from i to $a\,c$, we get the intersection i'; and a parallel to $a\,a'$ through i' will give the intersections i'' and l. The distance $i''\,l = i\,l = l\,j$ of Fig. 3. The other widths $e\,f$, etc., are found in the same manner. The pointed ends $g\,c\,h$ should be left off each section, and a circular plate used, as suggested.

***

(459) How can I straighten a triangular boxwood scale that has become warped? I have thought that it might be adjusted by some process of steaming.

J. DE L., Cape Town, S. Africa.

ANS. Remove the varnish by an application of alcohol. Then steam until soft, and confine it forcibly in a straight position until dry. The drying may be hastened if you wish.

***

(460) Please give calculations in detail for the following: (a) The maximum load on the driving wheels of a locomotive being given as 11 tons (22,000 pounds), and the speed as 35 miles per hour, what is the weight of steel rail required for the track? (b) What is the ultimate strength of a steel rail, the weight of which is 45 pounds per lineal yard, when carried on ties that are 2 feet 9 inches, center to center, made of $8'' \times 4\frac{1}{2}''$ timber? Assume a suitable section of rail. Give also the *safe* load. (c) What size of pump will be necessary to deliver 150 gallons per minute from a well, in which the pump can be located 6 feet above the surface of the water, the delivery to be 195 feet above the pump—the water to be conveyed a horizontal distance of $1\frac{1}{4}$ miles, through a line of pipes in which there are three bends of 150, 800, and 500 feet radii, respectively? Also explain how to calculate the size of boiler required for above pump. (d) On the railroad here, several $46\frac{1}{2}$ pound steel rails have recently broken. They are Ebbw Vale steel, ties 2 feet 9 inches center to center; the fracture shows splendid metal. How would you account for the breakage? (e) What is

the advantage of a high percentage of carbon in steel rails? (*f*) What is the advantage of a low percentage of phosphorus?

R. W., Coolgardie, Western Australia.

ANS.—(*a*) It is almost impossible to calculate the stresses in a rail due to a running train. Some of the factors that must be considered (and that vary so much, under different circumstances, as to make any attempt at a rational computation of the stresses almost useless) are the forces due to the thrust of the connecting-rod, the lack of perfect counterbalance in the driving wheels, inequalities in the track, and the rolling or surging of the locomotive. In present American practice, the loads allowed on a single wheel are roughly as follows: For rails weighing from 28 to 45 pounds per yard, the maximum wheel load is 4,000 pounds; for rails weighing from 45 to 65 pounds per yard, 10,000 pounds; for rails weighing from 65 to 80 pounds per yard, 15,000 pounds. (*b*) The theoretical load required to break a beam supported at the ends and loaded at the middle is

$$W = \frac{4SI}{cl},$$

where W = load in pounds;
S = ultimate tensile or compressive strength of the material of which beam is made;
I = moment of inertia of the section of the beam;
c = distance from the center of gravity to the extreme fiber of section;
l = length of beam in inches between supports.

Assuming an "American Standard" rail section weighing 45 pounds per yard, we find in tables that the values of I and c are 8 and 1.8, respectively; assuming also that the rails are rolled from steel having a maximum tensile strength of 85,000 pounds per square inch, and that the supports are at the center of the ties, the theoretical load under which the rail will break is

$$W = \frac{4 \times 85{,}000 \times 8}{1.8 \times 33} = 45{,}800 \text{ lb., nearly.}$$

With a steady load, it would be safe to load the rail to about one-fourth of this, say 11,000 pounds; with a variable load, the maximum should be not greater than 5,000 or 6,000 pounds. (*c*) A detailed solution of this problem would require more space than can be given here. We would recommend the use of a 4-inch pipe, in which case we would use a pump having an 8-inch water cylinder, and a 12-inch steam piston with a 12-inch stroke. A 5-horsepower boiler would be ample for such a pump. (*d*) It is impossible to give an intelligent opinion in regard to the causes of the breakage of the rails without knowing more of the conditions. (*e*) A large percentage of carbon makes rails hard and strong, thus increasing their resistance to the wear of the wheels. Too much carbon, however, makes the steel brittle and liable to be broken by shocks. (*f*) Phosphorus makes steel "cold short," that is, brittle and easily broken when cold. The greater the percentage of carbon, the more serious in its effects does the presence of phosphorus in the rail become.

***

(461) I have a shaft, Fig. 1, which, when made up, is as shown in Fig. 2. A split ring r is placed around the neck of the shaft as shown, and a solid ring r' is then shrunk on the first one. The head H is then put on from the opposite end, and then the material M is put in place around the shaft and subjected to hydraulic pressure; and, while the pressure is on, the other head H' is put on, and also the other rings, as before. The pressure is then taken off. Now, the material being under pressure, has a tendency to increase the distance between the heads, which effort is taken up by the rings. Will you please answer the following: *First*, what are the strains and stresses this shaft is subjected to, and what are the portions of the shaft to which each of these strains and stresses is applied? *Second*, which portion of the shaft will give way first? *Third*, will the shoulders at c, Fig. 1, give way before the portion L; also, what are these strains or stresses called, and how can they be calculated? The shaft is steel, the heads cast iron, and the rings wrought iron.

H. W. B., Philadelphia, Pa.

ANS.—You do not say what the material is. It may perhaps *set* under the pressure and so form a solid block, having no tendency to alter its form. We will suppose, however, that it is some elastic substance whose tendency is to recover its shape directly when the hydraulic pressure is removed. In that case

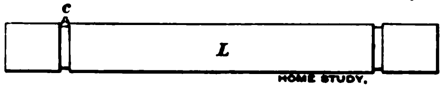

FIG. 1.

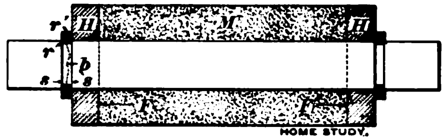

FIG. 2.

the shaft will be put in tension, the material exerting a pressure endwise on the heads. A lateral compression on the part L will also follow, due to the compression of the material. Here again it depends on whether the material is free to move laterally or not. Suppose, on the one hand, that, while the pressure is being applied, the whole arrangement is enclosed in a bushing or cylinder, and that, when the pressure is taken off, the shaft is pulled out of the cylinder. The material will then be free to expand laterally all around the shaft, and the push on the heads will be a certain quantity, say F. Again, suppose that, when the pressure is withdrawn, the shaft remains in the cylinder; in that case, the expansion of the material has to take place in an endwise direction. In this latter case, the push F' on the heads will be greater than before. If the shaft breaks, it will certainly do so in the corners c, in preference to any section such as shown at b. These corners ought to be filleted. In your case use a fillet having a $\frac{3}{16}$-inch radius; this will leave a good bearing for the rings; make the fillets on the latter slightly larger, so as to make sure of their having a fair bearing on the flat face of the shoulders s, s. The actual stresses cannot be calculated; they depend on the pressure applied, the nature of the material M, the elasticity of the shaft, and so on.

***

(462) (*a*) Can you tell me how to make a strong battery with which to run a small battery motor? (*b*) On what principles does a rotary transformer work? (*c*) How shall I calculate the number of revolutions that a dynamo will make?

C. McM., McMechen, W. Va.

ANS.—(*a*) As battery motors are usually made to operate under an E. M. F. of from 2 to 10 volts, five cells, such as described below, will be found sufficient to run a motor. Procure five glass jars, 5″ × 7″ (this is a standard size), or use any others you may have, that are of about those dimensions. Each cell is to contain one zinc plate, 3″ × 7″, flanked on either side by a carbon plate of the same dimensions. Connect both carbon plates to one terminal, and

attach the other to the zinc plate. A good contact with carbon is hard to make, so the best way to do would be to electroplate the top of each carbon plate with copper, and to solder a wire thereto. For a solution mix 1 part of bichromate of potash by weight, 2 parts of sulphuric acid (1.8 specific gravity), and 12 parts of water. The bichromate of potash is first pulverized, and then added to the sulphuric acid, stirring all the time with a glass rod or tube. The required amount of water should be held in another vessel, and the solution of bichromate of potash in sulphuric acid slowly added. When the solution is cool, it is ready for use. Mix such an amount that each jar will be filled within 2 inches of the top ; and, when the battery is not in use, remove the zincs from the various cells. Connect the cells in series, and you will have a battery whose E. M. F. is 10 volts, and that will give a current discharge sufficient to operate a good-sized battery motor. (*b*) A rotary transformer is generally a combination of an alternating-current motor and a continuous-current dynamo, or vice versa. There may be either two separate machines rigidly coupled, or mounted on the same bedplate, or there may be a common armature core carrying both the alternating- and continuous-current windings. In the latter case, which is by far the more common, there is a commutator at one side of the armature, and collecting rings at the other side. The principles involved in the operation of a rotary transformer are identical with those involved in the theory of the two machines of which such a transformer is constructed. The current coming from the line as either a two- or a three-phase alternating current, passes through the alternating winding, and rotates the armature, and the armature performs the function of a direct-current generator. (*c*) The formula for finding the number of revolutions n per second, is,

$$n = \frac{E \times 10^8 \times 80}{NC},$$

where, E = E. M. F. in volts given by the dynamo ;
N = total number of lines of force urged through the armature core ;
C = number of conductors on the periphery of the armature per pair of poles.

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(463) (*a*) Kindly give me the name and price of a good book on the designing of machinery—engines and boilers especially. (*b*) Referring to HOME STUDY MAGAZINE, March, 1897, Answers to Inquiries, No. 34, please explain how the location of the saddle pin equalizes the cut-off. T. A., San Francisco, Cal.

ANS.—(*a*) A thorough and proper study of the engineering branches you refer to would necessitate the purchase of several special treatises—an expensive procedure. About the best individual work for your purpose is David A. Low's "Mechanical Engineer's Pocket Book," price $2.50, obtainable from The Technical Supply Co., Scranton, Pa. (*b*) Due to the setting back of the saddle pin from the link arc, the link as a whole alternately rises and falls. Now, the more the link is hooked up, the earlier the cut-off, while the less it is lifted, the later the cut-off. Again, the net result of the action of the main and eccentric rods, and of the position of the eccentric-rod pin behind the link arc, is that on the outstroke the cut-off is too early, and on the return stroke it is too late. Now, by offsetting the saddle pin, we cause the link to fall on the outstroke and rise on the return stroke, the result being that the cut-off takes place later on the outstroke and earlier on the return. Now, this is exactly the opposite of the net effect of the errors just alluded to, and is therefore what we want. The only thing to do is to secure the right amount of offset. This can be done, and is done in the drafting-room, but it is generally found by trial, also, after the engine is built and has been supplied with wheels, a special temporary saddle being used for the purpose.

***

(464) A man dug a well just 6 feet in diameter ; after getting a certain distance down, he encountered a perfectly cylindrical log just 6 feet in diameter, the axis of which passed through the axis of the well and at right angles to it. In digging through the log a circular hole exactly 6 feet in diameter was made. How much wood did he remove?
O. S. P., Lisbon, Ohio.

ANS.—For method of solving this problem, see HOME STUDY MAGAZINE, June, 1898, Answers to Inquiries, No. 215.

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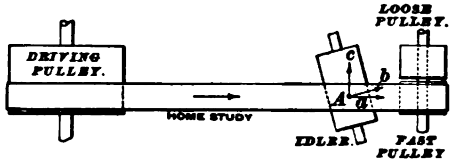
(465) Kindly explain why the belt in the enclosed sketch runs to the lowest point of the idler, causing the belt to shift from tight to loose pulley and vice versa, according to the position of the idler. The



idler is changed from one position to the other by means of a rope, and when the belt is to be shifted the idler is forced against the belt either as shown, when the belt will move to the loose pulley, or tilted the other way, to move the belt from the loose to the fast pulley. H. J. E., Norwich, N. Y.

ANS.—In the above diagram the belt is running on the fast pulley. If the idler is making an angle with the belt, as indicated, it will move the belt over to the loose pulley. The following explanation will show why the idler is able to cause this lateral motion of the belt : Let a point A on the belt be selected. If this point is not subjected to any outside influence, it will travel in a direction indicated by the arrow a. If, now, the idler is forced against the belt, it will have a tendency, by means of its frictional pull, to propel it in a direction indicated by the arrow b. In which of these two directions the point A will travel depends on the pressure of the idler against the belt ; the stronger this pressure is, the more will the direction of its motion conform with that of the arrow b. In like manner each successive part of the belt, passing over the idler, will move in a direction more or less conforming with the direction of the arrow b ; the result will be that the belt as a whole gradually moves in the direction indicated by the arrow c and changes over to the loose pulley. If the idler is tilted in the opposite direction, the belt is returned to the fast pulley, for reasons already given.

***

(466) What is the comparative cost of elevating material such as grain 50 feet, then conveying it 50 feet, by means of a belt-and-bucket elevator and by means of a worm conveyer?
A. W. C., Portland, Ore.

ANS.—The following comparison is made on the basis of equal delivery in each case. In the case of the elevator, the work performed is that of raising the material through a vertical height of 50 feet, and a certain work of friction. In the case of the conveyer, all of the work is due to friction. The friction due to the empty elevator is much greater than that due to an empty conveyer, but the friction of the material, as it is pushed along the conveyer trough, is large. This, however, will not, in any case, equal the dead-weight of the material. The work of operating the elevator is therefore in excess of the work of operating the conveyer for equal deliveries. Much

depends upon the setting of the machines and their condition; but, in practice, under equal conditions we may estimate upon the elevator consuming double the power used in the operation of a worm conveyer.

***

(467) I have come across the following problem in a very old work on algebra: "Let a square be divided into 9 equal squares. It is required to dispose the numbers 1 to 9 through them so that the sum of every three, taken laterally or diagonally, may be equal to 15. *Solution:* Suppose it done as in Fig. 1, and the numbers represented by symbols, *a*, *b*, *c*, etc." At this point a page of the book is missing. Kindly explain the solution of the problem. Is not this the "magic square" so much spoken of a few years ago?

F. W. P., Brooklyn, N. Y.

ANS.—The first n^2 natural numbers are said to be arranged in a magic square if the sum of each row, taken horizontally, vertically, or diagonally, is $\frac{1}{2}n(n^2+1)$. When n is 3, we have the simplest magic square, which is the one referred to in the question; in Fig. 2, we see that the sum of each row is $\frac{1}{2}n(n^2+1) = \frac{3}{2}(3^2+1) = 15$. Magic squares for odd values of n can be constructed by a simple rule,

a	*b*	*c*
d	*e*	*f*
g	*h*	*m*

HOME STUDY

FIG. 1.

4	9	2
3	5	7
8	1	6

HOME STUDY

FIG. 2.

which we shall explain by showing how to arrange the first 49 numbers in a magic square. Write the 49 numbers in their natural order in a square *A B C D*. Form a new square *E F G H* by joining the middle points of the sides of *A B C D*. Divide *E F G H* into

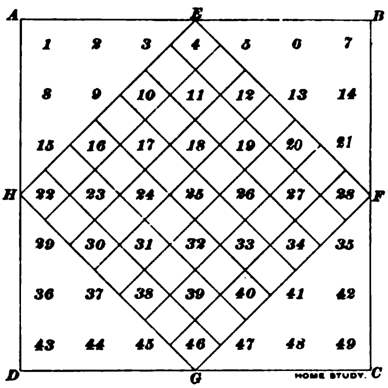


FIG. 3.

49 equal squares, as shown in Fig. 3. It will be seen that 25 of these small squares are occupied by numbers, and it only remains to place the remaining 24 numbers in the proper squares. Take the numbers 5, 13, 21, 35, etc., which are nearest to the sides of the square *E F G H*, and carry each one obliquely up or down the row in which it stands to the farthest vacant square. Next, take the numbers 6, 14, 42, 48, etc., which are next in order from the sides of *E F G H*, and carry each of them obliquely in its own row to the most remote vacant square. Proceed in this way till all the numbers are located in squares, and the result will be the magic square of the first 49 numbers, as shown in Fig. 3. The sum of each row is $\frac{1}{2}n(n^2+1) = \frac{7}{2}(7^2+1) = 175$. The construction of

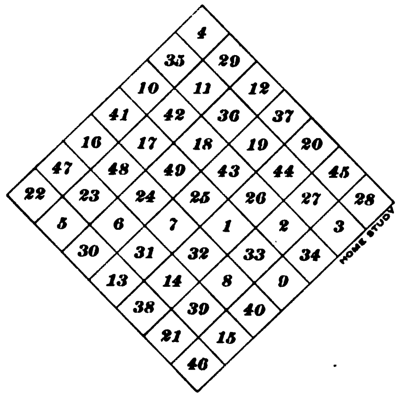


FIG. 4.

magic squares of even orders is more complicated, and cannot be explained in the space at our disposal. It is to be noted that no magic square can be constructed for the value $n = 2$; that is, the numbers 1, 2, 3, and 4 cannot be arranged in a magic square. When $n = 4$, the magic square consists of the rows 1, 12, 8, 13; 15, 6, 10, 3; 14, 7, 11, 2; and 4, 9, 5, 16; the sum of each row being $\frac{1}{2}n(n^2+1) = \frac{4}{2}(4^2+1) = 34$.

***

(468) (*a*) How can I ascertain the amount of iron required to cast a solid 12-inch cube? (*b*) As the size of pattern varies, how do you gauge the weight of iron required? (*c*) What gives the great strength to cast iron? (*d*) What is silicon, and in what ways does it affect iron? A. McK., Philadelphia, Pa.

ANS.—(*a*) A cubic inch of cast iron weighs about .26 pounds; a 12-inch cube contains 1,728 cubic inches, consequently, the 12-inch cube will require 1,728 × .26 = 449.28, say, 450 pounds of iron. The quantity of metal that must be melted to furnish this amount depends on the losses in the cupola and ladles, and the iron that goes into sprues, etc.; these items vary greatly with the practice of the foundry. (*b*) The best way to estimate the weight of iron required for a given casting is to compute the volume of the casting as nearly as possible in cubic inches, then multiply by .26, as above, and add for waste according to experience. (*c*) Cast iron is composed of metallic iron, combined with small quantities of various elements, the most important of which are carbon, silicon, manganese, phosphorus, and sulphur. Of these elements, the ones that are generally found in greatest quantities in cast iron, and have the greatest influence on the strength of it, are carbon and silicon. The carbon in cast iron comes mostly from the fuel—coke, coal, or charcoal—used in the blast furnace. It occurs in iron in two forms, known as *combined carbon*, that is, carbon chemically combined with the iron, and *graphitic carbon*, a form of carbon nearly identical with graphite (the material of which "lead pencils" are made), which is mechanically mixed with the iron. The proportions of combined and graphitic carbon vary in different grades of cast iron. In gray cast iron, a large part of the carbon is in the graphitic form, the dark color being due to the particles of graphite which show when the iron is broken. The carbon in white iron is nearly all in

the combined state. Silicon is a chemical element which is never found uncombined, but is very widely distributed through nearly all soils and rocks as *silica*, a chemical compound of silicon with oxygen, which forms the greater part of sand and sandstones. In the blast furnace, part of the silicon, which is always found mixed with the ore, gives up its oxygen and combines with the iron. Silicon has an important effect on the properties of cast iron, principally from its influence on the forms of the carbon. If the percentage of silicon is small, most of the carbon takes the combined form, and the iron is white, hard, and brittle. As the percentage of silicon is increased up to a certain limit, most of the carbon takes the graphitic form, and the iron becomes gray, soft, and tough. Thus, it is found that, by adding "silicon pig," a grade of cast iron containing a large percentage of silicon, to white iron, a fine quality of gray iron can be made. If the percentage of silicon is too great, the iron loses its strength, and becomes weak and brittle. Silicon also has a great effect on the casting qualities of iron; it tends to make the castings solid and free from blowholes, and affects the shrinkage to a considerable extent.

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(469) (*a*) What would you recommend as the most practical way of heating a swimming bath 100 feet by 40 feet? (*b*) What is the best temperature for a swimming bath? (*c*) What kind of boilers and what size would you recommend, assuming the quantity of water passing through the bath to be 60,000 gallons every 24 hours? (*d*) Do you consider 60,000 gallons too much or too little? F. E. A., Butte, Mont.

ANS.—(*a*) See HOME STUDY MAGAZINE, September, 1897, Answers to Inquiries, No. 358. The question there asked relates to swimming baths, and its answers will give you the necessary information. (*b*) About 90° F. But you should arrange the temperature to suit the requirements of your patrons. Place a thermostatic damper regulator on the heater to automatically control the temperature of the bath. (*c*) This information is embraced in the answer to (*a*). (*d*) This depends upon the number and condition of the heaters. It would appear, however, that 60,000 gallons of fresh water every 24 hours are quite sufficient. You should control the amount according to the requirements of the bath.

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(470) (*a*) What is the formula in general use for making a blueprint solution? (*b*) How is the displacement of a ship calculated when the dimensions are given? (*c*) In mechanical drawings, why are the shaded sides of a cylinder represented by thick lines? (*d*) What curve do you think the best for gear teeth? H. D. B., Baltimore, Md.

ANS.—(*a*) The article entitled "The Duplication of Drawings" in this number will give you the information. (*b*) Displacement, in the technical sense in which it is applied to ships, or any other floating bodies, refers to the displacement of the water by the total or partial immersion of any object placed in it. The volume of water displaced may be measured in cubic feet or in tons, and the weight of water displaced is called the *displacement*. By the application of a simple method known as Simpson's rules, the volume of the immersed portion of a ship can be ascertained, which, if considered as water and divided by 35, will give the displacement in tons. But, as vessels vary in form considerably, the mere length, breadth, and draft of a ship cannot be multiplied together for the displacement; hence, a *coefficient of fineness* is employed in computing the displacement. Knowing the extreme dimensions of a vessel and the coefficient of fineness, the exact displacement can be easily arrived at. For example, take a vessel 100 feet long, 20 feet broad, and floating at 8 feet draft, the coefficient of fineness being .6. The displacement would be,

$$\frac{100 \times 20 \times 8 \times .6}{35} = 274.2 \text{ tons.}$$

(*c*) Shade lines in mechanical drawings are a conventional way of giving character to the parts represented; they make it easier to read the drawing; and, in order to be consistent, every part, whatever its shape may be, should have its outline thickened on the shade side. (*d*) The involute is by far the best for all ordinary gear-wheels.

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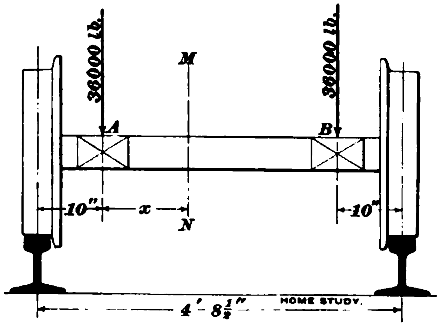
(471) If, referring to the accompanying sketch, the loads are as shown, what should be the diameter of the axle? Is the shaft considered as a cantilever 10 inches long? How would it be considered if the bearings were 10 inches *outside* the wheels? E. L. M., Joliet, Ill.

ANS.—By reason of the symmetrical loading of the axle, each rail reaction must be equal to 36,000 pounds. To find the maximum bending moment, consider any section MN at a distance x from the center of the journal A. The moment of the load at A, about the center of this section, is 36,000 x, and the



moment of the left reaction is 36,000 $(10 + x)$; hence, the bending moment at the section is,

$$36{,}000\,(10 + x) - 36{,}000\,x = 360{,}000 \text{ inch-pounds.}$$

This moment is, therefore, independent of x, and is the same for all sections between A and B. The moment of resistance of the circular section of diameter d is $\frac{1}{32}\pi d^3 S$, where S is the safe working stress; hence, $\frac{1}{32}\pi d^3 S$ = bending moment = 36,000,

or, $$d^3 = \frac{32}{\pi} \times \frac{36{,}000}{S}.$$

If we assume $S = 12{,}000$ pounds, a fair value for steel,

$$d^3 = \frac{32}{\pi} \times \frac{36{,}000}{12{,}000} = 306, \text{ and } d = 6\tfrac{3}{4} \text{ inches.}$$

The bending moment at the journal is the same as though the portion of the shaft between the journal and wheel were a cantilever 10 inches in length, but there is no advantage in assuming it to be a cantilever. If the bearings are outside the wheels, the character of the loading is precisely the same as in the figure, except that the forces at the ends are the loads instead of the reactions; and the bending moment is also the same, 360,000 inch-pounds.

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(472) (*a*) I have an electromagnet used as a hammer to record watchman's time. There are 3¼ ounces of No. 36 silk-covered wire on each spool; the distance between the electromagnet and the magneto-generator is 500 feet, connection being made with No. 20 wire. A manufacturer's catalogue gives the resistance of 500 feet of No. 20 wire as 5.06 ohms, and of 3¼ ounces of No. 36 as 1,100 ohms; giving a total of 5.06 + 1,100 = 1,105.06 ohms. If a magneto-generator made of 4 steel magnets formed of ¼" × 1¼" × 10" bars bent U-shaped will ring through a resistance of 5,000 ohms, will a magneto-generator made of 11/16 of

that amount of steel ring through 1,100 ohms? Or will a single steel magnet of ½″ × 2½″ × 8″ bar bent U-shaped do the work required above? (*b*) Referring to the dynamo described in HOME STUDY, March, 1896, Fig. 6 of page 46, is there any advantage in making so small a generator? Will it work at a slow speed, produced by hand motion? (*c*) What will be the lighter form—steel magnet or electromagnet—and what percentage of weight will be saved in the lighter one? (*d*) Is it necessary to have a commutator in so small a generator for the purpose mentioned in question (*a*)? (*e*) Can a generator, weighing 2½ pounds, operate the magnets described above, and what is the simplest form of generator you can suggest? D. H., Chicago, Ill.

ANS.—(*a*) The total resistance of the apparatus you describe is 1,100 + (2 × 5.06) = 1,110.12, there being 1,000 feet of No. 20 wire. A magneto-generator with a field magnet ½″ × 2½″ × 8″ should be able to ring through the above resistance, provided that it is magnetized to the same degree as the field of the magneto with four magnets. (*b*) This machine is only diagrammatic, and is not designed with reference to any particular use. (*c*, *d*, and *e*) A generator such as you desire to make will have to be self-exciting, and, therefore, a direct-current machine. In such a case, a commutator is necessary. Further, with a simple electromagnetic field, the time required to excite it at each station would prohibit the use of the machine for the purpose you mention. It is evident that a permanent field, such as you suggest, will be required, and also a commutator for providing a direct current.

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(473) (*a*) Is there on the market a dynamo that can be run under water—a waterproof dynamo? (*b*) The space that I can allow for the dynamo is 2′ 6″ × 18″ × 18″; what power could be developed by a machine of such dimensions? (*c*) If such a dynamo is not on the market, what size comes nearest to the given dimensions? J. H. K., Mass.

ANS.—(*a*, *b*, and *c*) The Riker Motor Co., 45–47 York St., Brooklyn, N. Y., make a waterproof motor which will probably answer your purpose. Write to them, telling them exactly what you want, and they can probably supply the desired machine.

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(474) (*a*) What is considered good practice for dynamo fuses for machines of the following capacities: 470, 360, 240, and 200 amperes? The fuses are intended to protect the machines only, and not to carry any stated number of lamps. (*b*) In certain Weston ammeters a German silver block is used, and only a small part of the current passes through the meter. What is the principle involved? (*c*) Please recommend books on refrigeration, and steam heating of buildings. J. B. S., New York, N. Y.

ANS.—(*a*) The degree of temperature at which a fuse melts depends on physical conditions, such, for instance, as air-currents and the size of fuse terminals. For ordinary working, the following sizes of fuses will be found satisfactory: For the machine whose capacity is 470 amperes, use a standard fuse with copper terminals of a rated capacity of 500 amperes. The fusing current for such a fuse is about 550 amperes. This margin allows for an overload of about 16 per cent.—not too large for a good machine. For the three other machines, of capacities of 360, 240, and 200 amperes, use fuses of the same style, whose rated capacities are, respectively, 400, 250, and 200 amperes. Fuses selected of these capacities allow for overloads of about 20 per cent., and will melt at any load above those. Fuses are rather erratic at times, and if sudden high overloads occur, we would recommend that you employ automatic magnetic circuit-breakers. (*b*) In connection with some Weston ammeters a block is employed, through which all the current passes. It is made of an alloy whose temperature coefficient is small. In consequence, the drop of potential between the terminals, to which the wires from the ammeter are connected, is proportional to the current strength. The ammeter is, therefore, calibrated to indicate the various current strengths, corresponding to the drops in potential which they cause. (*c*) "Heating and Ventilating Buildings," by R. C. Carpenter, can be obtained from The Technical Supply Co., Scranton, Pa. For information on refrigeration, see HOME STUDY MAGAZINE, October, 1898, Answers to Inquiries, No. 420.

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(475) How is silver solder made, and what is the proper way to use it? A. B. L., Wells, Minn.

ANS.—The alloys known as silver solder have varying compositions, which vary with the kind of material to be brazed. The following table gives a few compositions:

COMPOSITION OF SILVER SOLDER.

Kind.	Silver.	Copper.	Brass.
For jewelers	19 parts.	1 part.	1 part.
For silver, brass and iron	1 part.		1 part.
For steel joints	19 parts.	1 part.	1 part.

A more fusible silver solder consists of 5 parts of silver, 5 parts of zinc, and 5 parts of brass. Scrape or file the parts to be joined. Place the cleaned faces together. Lay a piece of solder over the joint. Sprinkle a little damp calcined borax over the joint. Now apply heat until the solder melts and runs into the joint; then let the work stand until it cools off.

***

(476) (*a*) I find that several of the meters in our system do not register correctly. I see no means of overcoming the trouble except by friction, which I think is not the proper method; hence, the following question: Is there any way to adjust the Duncan meter for alternating currents? (*b*) What is the correct method of fusing for primary and for secondary currents? W. E. R., Cape May, N. J.

ANS.—(*a*) There is a friction compensator in front of the cylindric armature of the wattmeter, designed to be used for adjusting the speed of the meter on one lamp. This is with the view of eliminating the tendency of the meter to run slowly on light loads, after being installed and operated for some time, resulting from the jewel probably becoming rough, or the entrance of dust or other obstructive matter. If the meter, upon being tested, is found to be running too slowly on one lamp, this compensator should be moved to the right by unscrewing the set-screw which holds the arm supporting it. When the meter is very slow on one light, and the compensator has little or no effect upon the speed, it is very probable that the jewel is cracked or otherwise injured, in which case a new one must be inserted. Care must be exercised in making the necessary adjustment that too much starting torque is not given, as this might result in the meter having a tendency to move on no lights. Write to the Fort Wayne Electric Corporation, Fort Wayne, Ind., for pamphlet relating to Duncan meters, which will be sent to you free of charge. (*b*) Fuses in the primary circuit should be located at two points, with reference to a single transformer and machine. The first is in the main machine circuit between the machine and its main switch; the second is in the circuit before the meter is reached, that is, directly after leaving the feeders. In the secondary circuit, fuses should be inserted in the circuit between the lamps and the secondary

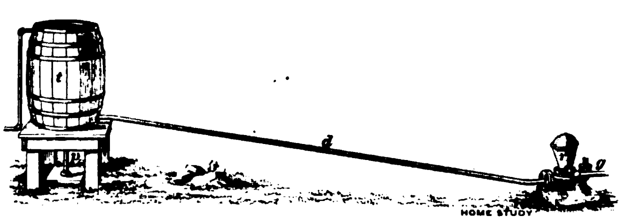
terminals of the transformer. Enclosed fuses should be used in all cases, that is, mounted in fuse boxes designed to be used for the above purposes. In a house system, fusing can be done as in the direct-current system.

* * *

(477) (*a*) How is the flow of artesian wells measured? (*b*) I wish to connect a No. 3 hydraulic ram to a 2-inch artesian well that flows about 4 to 5 miners' inches 1 foot from ground and raises 6 to 7 feet high, but does not flow that much water at that height, but 1 or 2 inches only. What I want to know is how I must connect the ram so as to get the proper force to run it. The distance horizontally is 350 feet, and it is 25 feet to the top of the tank. How must I set the ram from the well? Ought I to use a stop-cock for regulating the pressure of water? (*c*) Should the up pipe be taken over the top of the tank, or up through the bottom?

J. G. R., San Jacinto, Cal.

ANS.—(*a*) The flow of artesian wells can be measured in a variety of ways, depending on the quantity of water, the location, and the degree of accuracy required. If the flow is small, as is the case with your well, the most satisfactory method is to use a tank, carefully noting the time in which a tank whose size is known is filled by the water from the well. If the discharge is too great to admit of this method of measurement, it is best to use a weir. (*b*) We would suggest the following method of connecting the ram with the well. Let the well discharge into a tank *t* as shown in the sketch, the pipe *p* from the well being connected to the tank *t* near the bottom, and the tank being placed so that its top is about as high as the well will raise the water. Connect the drive pipe *d* of the ram *r* to the tank *t* near the bottom, and lead it to the ram as directly as possible. From your statement of the conditions, an oil barrel, holding about 40 gallons, and placed on a platform so as to bring its top about 7 feet from the surface of the ground, would probably make a satisfactory tank. The distance of the ram from the tank depends on the diameter of the drive pipe; about 30 feet would probably give good results. With the arrangement shown in the sketch, no stop-cock is required. (*c*) The discharge pipe should be taken in at the top of the tank.



* * *

(478) Please explain the method of laying out bevel and miter gears. C. N., Torrington, Conn.

ANS.—See HOME STUDY MAGAZINE, September, 1897, article entitled "How to Lay Out Gear Teeth."

* * *

(479) When being examined for an engineer's license I was asked the following question: How would you tell the vacuum you were getting in a Corliss engine if the vacuum gauge broke?

MACHINIST.

ANS.—By means of a glass tube and a cup of mercury, a vacuum gauge could be rigged up that would serve the purpose of the broken gauge; or, the temperature in the condenser could be found by means of a thermometer; then, by means of steam tables, the absolute pressure corresponding to this temperature is easily found. Having the absolute pressure, the vacuum in pounds per square inch can be found by subtracting it from 14.7; finally, the vacuum in inches of mercury is given by multiplying the vacuum in pounds per square inch by 2.04.

* * *

(480) Kindly inform me how to make a filter that will separate heavy cylinder oil from sawdust, dirt, water, etc. G. H. K., Dollar Bay, Mich.

ANS.—Such filters are on the market, and are in use in many engine rooms, the oil being collected from the different bearings and used over and over again. Write to Chas. A. Strelinger & Co., Detroit, Mich.; they can supply your wants. It will be much cheaper to buy one than to attempt to make it. The principle of these filters is very simple. A deep, circular pan, with perforated sides, is rotated at a high speed, and centrifugal force drives the oil outward through the perforations.

* * *

(481) (*a*) Will you please name the articles that are necessary to conduct small experiments with X-rays? (*b*) Can The Technical Supply Co., of Scranton, Pa., furnish them, and at what cost?

J. R. C., Salem, Oregon.

ANS.—(*a*) To conduct experiments with X-rays the amount of apparatus required is determined in a measure by the elaboration it is proposed to give to a series of experiments. What may be termed essential is the following apparatus: One induction coil, giving at least a 4-inch spark, or a static machine of equivalent capacity; one Crooke's tube, suitable for use with either the coil or the static machine; one fluoroscope; primary or storage battery (depending on circumstances); and one or more single plate-holders, for holding sensitized plates when making radiographs. A reversing switch may also be included in the outfit, for the purpose of reversing the connections of the battery to the primary coil. When a static machine is used, it is evident that a battery will not be required except where one is used to drive a motor for operating the static machine. (*b*) You can ascertain prices for complete X-ray outfits, such as are selected for amateur use, by writing to J. H. Bunnell & Co., 76 Cortlandt St., New York City, N. Y.; Western Electric Supply Co., St. Louis, Mo.; Western Electric Co., Chicago, Ill.

* * *

(482) What is the name of the white substance that forms on red pressed brick, and of the green substance that one often sees on buff pressed-brick walls? How can such walls be cleaned, and what can be done to prevent the substance again forming?

W. F., Richmond, Ind.

ANS.—Efflorescence on brickwork is due either to soda in the brick, which is drawn to the surface by capillary attraction when the brick is wet, or to pyrites in the clay, which forms sulphuric acid when the brick is burned, and this, uniting with the magnesia in the lime mortar, produces sulphate of magnesia on the surface of the wall. In either case, the efflorescence seldom appears until after the bricks have been thoroughly saturated with moisture, either when laid or during a heavy rain storm, and the time of its appearance may be delayed for several years. It may be removed by scrubbing the wall with a stiff brush and water, and then, when dry, applying a good coat of boiled linseed oil to make the brick impervious to moisture. This will prevent its reappearance for several years, after which the wall must again be scrubbed and oiled, as before.

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THE GAS BILL.

Thos. N. Thomson.

Do Not Blame the Company if Your Gas Bill is Higher Than Your Neighbor's—The Burners Are Often at Fault—How to Read Your Own Meter.

ARE you satisfied with the gas in your house? Are you sure that you are getting the greatest amount of light for the least amount of money? Are the monthly gas bills satisfactory? If so, you need not read this article, because it is especially written for those who complain of being robbed by the gas companies.

It has often been said that "corporations have no souls," and that they generally do as they please, without remorse of conscience. Now, to a certain extent, this may be true, but there are times when corporations in general, and gas companies in particular, are slanderously maltreated. The common practice of gas companies is to manufacture gas at a central station, and to distribute it among the residents of a city by means of extensive systems of pipes laid under the streets. The "consumers," that is, the patrons of the gas company, purchase the gas at a certain rate per thousand cubic feet, and the volume of gas "delivered" to each consumer is registered by a gas meter. These meters are the property of the gas company, and they are always attached to the gas pipes in such a manner that the entire gas-pipe system of any consumer connects to the outlet of the meter, while the service pipe, which brings the gas in from the street main, connects directly to the inlet opening. Dissatisfied consumers blame the meters for their big gas bills, and "chronic kickers" abuse the corporation and its officials, while the cause of all the trouble rests with the consumer himself. "He lies like a gas meter," is a common vulgarism, but the originator of the expression knew nothing about gas meters, or he would never have made use of such a simile. It is a fact that these much abused instruments do not always tell the truth, but when they err it is in favor of the consumer. This may appear ridiculous to those who pay gas bills, but it is true, nevertheless; indeed, owing to the peculiar construction of a gas meter, it cannot be otherwise. The mechanism of the meter is actuated by the gas flowing through, and if the parts are not in perfect condition, a certain volume of gas will pass through unregistered. The amount thus escaping will be great or small, according to

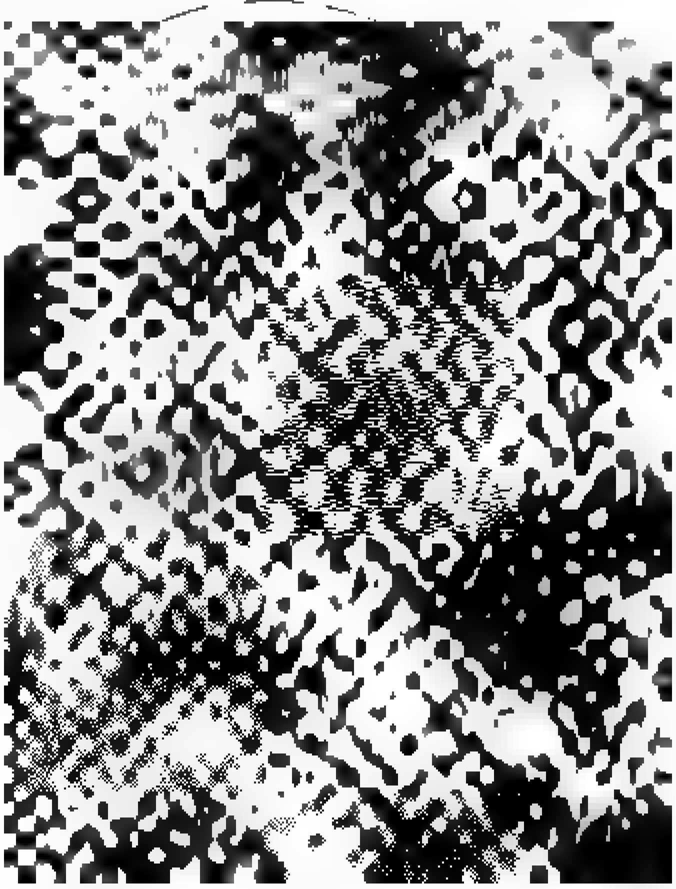


Fig. 1.

the extent of the imperfections, but, whatever the quantity, it certainly means money transferred from the vaults of the gas company to the pocket of the consumer. Cases have been known where meters did not register at all, and the consumers have burned gas month after month, without any charges being presented by the company. All meters

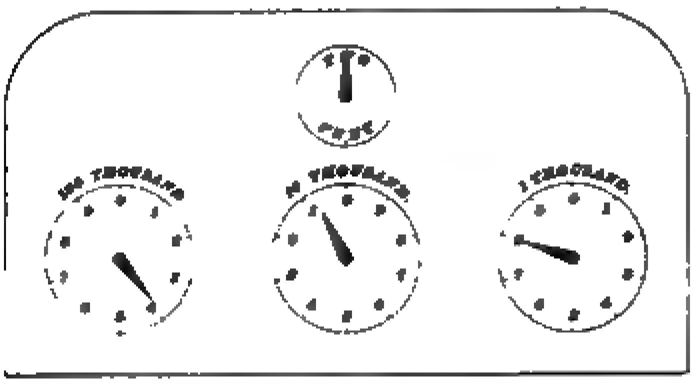


Fig. 2.

that are adjusted to register accurately when new, must, when the working parts deteriorate, err in favor of the consumer. Meters are condemned because they are not understood.

Seeing that an honestly adjusted meter cannot exaggerate the quantity of gas which passes through it, the question naturally arises, "where, then, does the gas go?" There are only two places for it to go. It must either leak from the pipes in the house or flow from the burners. But surely the gas does not escape seriously from the house pipes. If it did, its odor would make its presence known.

The pipe system in a building can easily be tested for leakage in the following manner: Light the gas at one of the fixtures and allow it to burn until the pointer on the *Two Feet* dial of the meter points exactly to one of the division marks as shown in Fig. 2. Now, shut off the gas quickly before the pointer gets beyond the mark. Be sure that all the gas cocks at the fixtures are shut, and see that the stop-cock at the meter remains open. Let the whole system stand unmolested for at least one hour, then examine the pointer. If it has not moved, you may be sure that no money is lost through any leakage from the pipes. This simple test, however, is not positive proof that the pipes are absolutely tight, because the leakage may be so small that the quantity of gas passing through the meter is not sufficient to actuate the registering mechanism.

Now, let us consider the gas burners. This is where the money goes. Investigations have repeatedly been made by experts, and their reports all show that consumers actually waste the gas themselves, either through ignorance or carelessness. In fact, the waste in many places is so extensive that barely one-half of the lighting power of the gas is utilized. It is safe to assert that from 20 to 25 per cent. of the gas used for lighting purposes is actually wasted, and the "kickers" are the people who waste the most.

It is not necessary to make scientific demonstrations with a photometer in order to prove to a sensible person that an ordinary "fishtail" burner is a great source of waste when it is not intelligently handled. To prove this statement it is only necessary to light one and turn on the full gas pressure. The excessive pressure will cause the flame to flare and burn with ragged edges, as shown at (*a*), Fig. 1. If the pressure is extremely high, a disagreeable, hissing sound will also be noticed. The illuminating power of such a flame is very low, and a considerable quantity of the gas is wasted; some even escapes into the atmosphere unconsumed, and vitiates the air in the room. Now turn the key gently until the flame assumes the shape shown at (*b*), Fig. 1, and it will be noticed that, while the size of the flame is decreased, its illuminating power is really increased. This is the economical flame from such a burner, and money is saved by simply checking the flow of gas and thus regulating the pressure at the "tip."

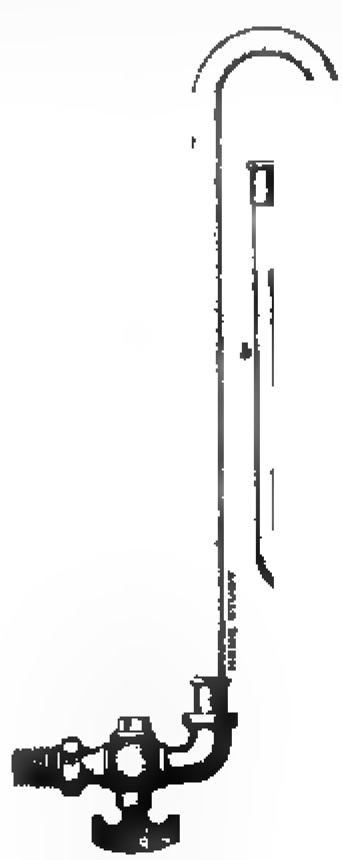


Fig. 3.

The flame shown at (*a*), Fig. 1, is a "gas waster" of the worst character, and yet how often we see it! The following table will give an idea as to how money can be "burned" with an ordinary No. 4 union jet burner.

A No. 4 burner is made to consume 4 cubic feet of gas per hour, at a pressure of .5 inch of water. This is the pressure which gives the most economical flame at an open burner. The table shows that the same burner, with a pressure of 2 inches, will waste more than

50 per cent. of the gas registered by the meter, and the gas bill will be twice as high as it should be. Suppose, now, that you have ten common, 4-foot lava-tip burners in the house, that each one is in use, on an average, 3 hours every night, that the gas pressure is 2 inches, that all the burners run full blast, and that the cost of the gas is $2 per thousand cubic feet. The quantity consumed at the end of a month will be about

Number of burners		Consumption in cu. ft.		Days in month		Hours burning each night	
10	×	8.46	×	30	×	3	= 7,614 cu. ft.

The amount of your bill will be somewhere about 7,614 × $2 = $15.23. This is an honest bill which you will grudge to pay because you cannot see where the gas has gone.

Pressure in Inches of Water Column	Consumption in Cubic Feet per Hour.	Unit Efficiency Candlepower.
0.5	3.91	3.00
1.0	5.62	2.41
1.5	7.10	1.89
2.0	8.46	1.50
2.5	9.62	1.36
3.0	10.51	1.12

Now, suppose you take an economical streak and consult an intelligent plumber, the object being to ascertain how your gas bills can be reduced to a minimum without decreasing the brilliancy of the illumination. Like a doctor, the plumber tries to get you to explain the "symptoms of the case," and you, like his other customers, persist in talking so ridiculously that he decides to go up and see for himself. The first thing he does is to get the facts from your wife. Then he reads the pressure at one of the burners with the glass **U** tube shown in Fig. 3. This tube is filled with water up to the zero mark, and of course the water stands at the same level in the two legs of the tube; but, when the gas key is opened, the pressure of the gas immediately forces the water down in the column *a* and consequently up in the column *b* until it reaches a mark, say, midway between 2 and 3 on the scale. This indicates a pressure of 2.5 inches, which is very modest indeed, the average pressure being in the neighborhood of 3 inches.

Now he asks you to light the ten gas jets. They are lighted in the usual manner, and he sees the waste at a glance. Every jet is turned on full force and they all blaze like (*a*), Fig. 1. That settles it. He goes back to the shop and writes out a report, in which he explains where and how the waste of gas (and consequent loss of money) takes place. He also states what should be done to prevent further loss, and very sensibly suggests that a pressure regulator be placed on the gas pipe near the meter so that the gas pressure throughout the building may be automatically regulated to that point best adapted for economical combustion. He also suggests that you remove the old burners and replace them with improved modern incandescent burners on the Welsbach principle. Finally, he says that he will be pleased to make all of these improvements for the sum of $21.50.

You now wonder if it will pay to go to this expense. Just do a little figuring. A Welsbach incandescent gas lamp, consuming 3 cubic feet of gas per hour, gives from 50 to 60 candlepower of light. Let us be modest and call it 50 candlepower which is 10 candlepower lower than the manufacturer's claim. These ten Welsbach lamps, in use for 3 hours each night for a month, would consume 3 × 3 × 10 × 30 = 2,700 cubic feet of gas—which, at $2 per thousand feet, will cost you $5.40 for the month. Place this amount against your old bill of $15.23, and you will find that you have saved almost $10.00. But this is not the only gain; you get about 3 times as much light as you had before.

Fig. 4.

In case some reader is not acquainted with the construction of the incandescent gas lamp of the Welsbach type, let us refer to Fig. 4, which shows such a lamp, complete, with the gas burning, and to Fig. 5, which is a section through the same lamp. The burner is of the ordinary Bunsen type. The

gas enters at *a* and the air at *i*. The mixture burns on top of a wire-gauze cover *b*, producing great heat but practically no light. This heat is transformed into light by a hollow tubular network, or mantle *c*, which is suspended over and around the burner by a wire support *d*. This mantle is composed of threads of an incombustible material, which becomes brilliantly incandescent when highly heated. It is made by saturating a delicately woven cotton fabric with a dense solution of earthy oxides, which is baked on the network. When the mantle is about to be used, its temperature is raised high enough to destroy the cotton fibers, leaving the coating of oxide standing as a network of fragile crust. This fragile nature of the mantles is at present the only drawback to the general use of incandescent gas lamps.

Now we will try to show how a consumer can read his own meter. Fig. 2 shows a meter dial of the ordinary type. When the pointers all point to the zero mark on their respective dials, the meter is said to be at *zero*. If the meter is at zero, and a certain amount of gas is allowed to pass through it, the number of cubic feet of gas passing through the meter will be indicated on the dials. If the meter is not at zero, however, the number of cubic feet of gas which has actually passed through during the time specified is equal to the difference between the number indicated upon the dials, before the gas was allowed to pass through the meter, and that indicated when the gas has flowed through. The top dial is marked *Two Feet*, which means when two cubic feet of gas have passed through the meter, the pointer of this dial will have made one revolution. When 1,000 cubic feet of gas have passed through the meter, the pointer of the dial to the right, which is marked *1 Thousand*, will have made one complete revolution, and the pointer of the *10 Thousand* dial will have moved from *0* to *1*. When the pointer to the right has made another revolution, the pointer of the middle dial will have moved from *1* to *2*, which means that two complete revolutions of the pointer to the right have been made. When the middle pointer has made one complete revolution, the pointer to the left will have moved from *0* to *1* on the *100 Thousand* dial, which means that $\frac{1}{10}$ of 100,000, or 10,000 cubic feet, have passed through the meter.

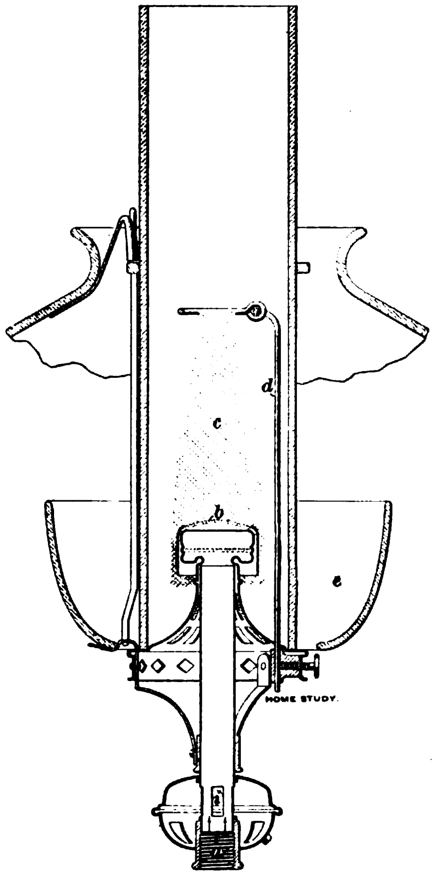


Fig. 5.

To read a meter dial of this description, first write down from each dial the figure which the pointer has just passed, then annex two ciphers to the right; the number so obtained will be the amount of gas in cubic feet which the meter has measured.

Thus, the pointers on the dial in Fig. 2 indicate that 41,800 cubic feet of gas have passed through the meter. When the pointer to the left has made one complete revolution, the process of indication is repeated. The pointers all move from the smaller to the larger figures, just like the hands of a clock.

Now that you can read your own meter, just watch the gas company closely, and discover that the officials are honest and your bills accurate. Then withdraw your doubts and feel at rest.

PROPERTIES OF MATTER.

Benj. F. La Rue.

DISTINCTION BETWEEN PHYSICAL AND CHEMICAL PROPERTIES—RELATION TO MOLECULAR CHANGE—CHARACTERISTIC AND UNIVERSAL PROPERTIES.

EVERY form of matter possesses certain properties which are peculiar to and characteristic of all matter of the same kind. Such properties are of two classes, namely, physical and chemical.

Physical properties are such properties of matter as may be manifest without change in the identity of the molecule. The physical properties of any form of matter may be recognized without changing it into something else. For example, we easily recognize in alcohol certain characteristic properties. It is a liquid, is transparent, has a certain specific gravity, and a peculiar taste and smell, etc. These various properties may be recognized simply by examining the alcohol as alcohol, and without in any way changing its identity.

Chemical properties are those which are not manifest without change in the identity of the molecule. The chemical properties of matter cannot be ascertained by any means that will leave it the same as it was before. Alcohol possesses the property of combustion; it can be readily burned. But this property cannot possibly be recognized by examination, however carefully the examination is made. That it possesses this property can be ascertained only by burning it. But it will then be alcohol no longer; it will have been changed into heat and gas. The alcohol had possessed this property ever since it became alcohol, but it could not manifest it without ceasing to exist as alcohol, that is, without changing the identity of its molecule.

Each chemical element which enters into the composition of a substance may be common to various substances, but the proportion in which the elements are combined is characteristic of each particular substance. Hence, chemical properties are characteristic properties. In what follows, however, the chemical properties of matter will not be further noticed, but attention will be directed chiefly to its physical properties

It may be well, now, to notice that, in addition to its characteristic properties, matter possesses certain physical properties that are common to *all* matter. Such properties are called *universal*, or *general*, *properties*. The most prominent universal properties of matter are extension, impenetrability, weight, inertia, porosity, compressibility, expansibility, elasticity, divisibility, mobility, and indestructibility. Only a few of these properties will here be specially noticed.

Extension is that property of matter which enables and requires it to occupy space. It relates to the size and form of a body, and comprehends the three dimensions of length, breadth, and thickness. It is an inherent and essential property that is common to every possible form of matter. It is involved in the very definition of matter, namely, *anything that occupies space*. No one can conceive of a body that does not occupy space, or take up room. Hence, it must have size —must have length, breadth, and thickness. Consequently, it must also have form, or shape.

Impenetrability is that property of matter which prevents a body from occupying, at the same time, the space occupied by another body. Two bodies cannot occupy exactly the same space at the same time. This is a direct result of the property of extension. A body occupies and requires space; it cannot exist without occupying space; and the same space, when thus occupied, cannot be occupied by another body. Examples illustrating this property are very common. If you fill a glass with water, you cannot put more water, or anything else, into it without forcing the water to run out over the edge of the glass.

Weight is the term commonly applied to the measure of the effect of gravitation. All bodies of matter possess weight, although we do not readily recognize this property in bodies whose weight is less than that of the medium surrounding them, as, for instance, the weight of a gas that is lighter than the earth's atmosphere. As commonly used, however, the term *weight* generally refers to bodies upon the earth's surface, and its meaning in this connection is sufficiently understood and does not require explanation here.

Inertia is that property of matter which

renders it incapable of changing its condition of rest or motion. We are prone to get the impression that all bodies tend to a state of *rest*, because most bodies with which we are familiar come to that state upon the earth's surface. But material bodies have no inherent tendency toward a state of rest any more than toward a state of motion. Matter is entirely incapable of changing its condition, whether of rest or of motion. When in motion, its tendency is to always continue to move in the same direction and at the same rate of motion, and it would always so continue if it were not opposed by some external force. Examples of the effect of inertia are to be found on every hand. A ball cannot throw itself; it requires the application of an external force to put it in motion. And, when put in motion by being thrown, it cannot stop itself, but would continue on in the same direction and at the same speed, were it not for the resistance of the air and the effect of gravity.

Elasticity is that property of matter which gives to all bodies the tendency to recover their original form and size when these have been changed by any external force. All material bodies possess this property, although some substances possess it only to a slight degree. Every known substance, when subjected to external pressure, will be reduced in size, because every known substance is, to some extent, compressible. If the pressure does not exceed certain limits, every known substance will, upon the removal of the pressure, recover its original size. Fluids are not elastic with reference to *form*, but are perfectly elastic with reference to *size*, without regard to the amount of pressure. Solids are elastic with reference to both form and size, within certain limits. If the pressure or force applied upon a solid body exceeds certain limits, varying with the substance, the body will not recover its original form and size, but will undergo permanent deformation.

Indestructibility is that property of matter which renders it incapable of being destroyed. We cannot by any possible means destroy matter. Science teaches us that the universe contains today, not only exactly the same amount of matter, but even the same quantity of each element, that it has contained ever since time began. Forms of matter have undergone changes that were great indeed, but not one particle, not even one elementary atom, has been either gained or lost. Water from the ocean is evaporated into the air by heat, and is carried by the winds out over the land, where, becoming condensed, it falls as rain upon the earth, and, finding its way to a watercourse, is again carried away to the ocean. But not one *iota* is destroyed—not even so much as the millionth part of the finest particle of mist. The sprout from the acorn, gathering sustenance from the ground and atmosphere, becomes a great tree; it is, perhaps, cut down and burned as wood, or it may stand until blown over by the wind and then lie upon the ground until it rots. In either case, its elements return partly to the ground and partly to the atmosphere, whence they came. But not one atom is lost or destroyed.

These two illustrations will serve to indicate, to some extent, the continued round of transforming change that is undergone by the material bodies composing the universe, without the slightest gain or loss. Matter is indestructible.

The characteristic physical properties of matter are numerous and of great variety. Each characteristic property is generally common to many different forms of matter, as a property, but, in the different forms of matter, varies greatly in degree, depending largely upon the intensity of molecular attraction, or cohesion and adhesion, inherent in each form. Among the most important characteristic properties of matter are hardness, tenacity, ductility, malleability, toughness, and brittleness.

Hardness is that property of matter tending to resist any attempt to force a passage between its particles. The hardness of a substance is measured, in a general way, by the degree of difficulty with which it may be scratched or indented by another substance. Hardness is a variety or special aspect of the molecular attraction, or cohesive force, which holds the particles composing any body in position and prevents disintegration. With reference to hardness, no fixed law can be stated. Certain substances possess the property to a high degree, while others do not. Some substances, also, which do not themselves possess the property to a very high degree, produce a great degree of hardness in certain other substances, when combined with them. Carbon is not itself a very hard substance, but a small percentage of it, properly combined with iron, produces exceedingly hard steel. Fluids do not possess the property of hardness.

Tenacity is that property of matter by virtue of which a force tending to tear its particles asunder is, by some bodies, resisted.

The *strength* of any material is due, principally, to its tenacity. That tenacity is also a particular aspect of cohesion will be at once recognized. The tenacity of any substance can be measured by ascertaining the greatest weight that can be hung from, and sustained by, a piece shaped in the form of a rod or wire, the area of whose cross-section is known. As the resistance will be uniform over the cross-section, if the amount of weight sustained is divided by the area of the cross-section, the quotient will be the tenacity of the substance per unit of cross-section. Hence, it is evident that, for any given material, *the tenacity is directly proportional to the area of the cross-section.* This is a well known and important law of tenacity. Four rods, each 1 inch square, will carry four times the load that can be carried by one of the rods. A bar of the same material, having a sectional area of 4 square inches, will carry as much as the four bars, or four times as much as one of the bars having 1 square inch of cross-section. In this country, the square inch is generally taken as the unit of sectional area for measuring tenacity.

Ductility is that property of matter by virtue of which some bodies are capable of being drawn out into wires or threads. Some substances are very ductile. Platinum wire has been drawn out to a diameter of only $\frac{1}{30000}$ of an inch. Glass, at a red heat, is exceedingly ductile. Most of the ordinary metals possess the property of ductility to a considerable extent.

Malleability is that property which renders some forms of matter capable of being beaten or rolled into thin sheets. Some of the common metals possess this property to a remarkable degree. Lead is very malleable, and can be rolled into very thin sheets. Steel has been rolled into sheets as thin as ordinary paper. Gold, which is the most malleable of all metals, has been beaten so thin as to require 282,000 sheets to give a thickness of 1 inch.

Toughness is that property of matter which enables it to undergo a limited amount of bending, twisting, and similar rough usage, without material injury. It is, however, probable that all substances are to some extent injured by even the smallest amount of bending or twisting, but the injury to some substances from a limited distortion is so slight as to be imperceptible. Toughness may be said to embrace, to some extent, the properties of ductility and malleability.

Brittleness is that property of matter which renders some bodies susceptible of being easily broken or fractured by a blow. A peculiar and important condition characteristic of this property is that certain substances, on being broken, always exhibit the same form of fracture. This fact is of great value in enabling geologists to recognize the composition of rocks. Most ordinary rocks are brittle and can be readily broken by a forcible blow.

Brittleness must not be considered as the opposite of hardness, or due to lack of either hardness, tenacity, or elasticity, for a substance may possess all three properties to a high degree and still be very brittle. Steel is much harder and more tenacious than copper; yet, at the same time, it is much more brittle. Glass is almost perfectly elastic, but also very brittle; the same may be said of some qualities of steel. Brittleness is more nearly the opposite of ductility, malleability, and toughness, especially of the last. A substance that possesses to a high degree the properties of ductility, malleability, and toughness cannot be very brittle. Indeed, in the physical tests of metals, the measure of ductility and the bending test for toughness are both accepted as indicating freedom from brittleness.

The above characteristic properties of matter are those of the most importance, as indicating the adaptability and value of any substance for any particular purpose. For the different members of important structures, and for all purposes where strength is required, a high degree of tenacity is essential, and a considerable degree of toughness is very desirable. For a cutting tool, hardness is the most essential property. For the manufacture of wire, ductility is the property desired; while, for many ornamental purposes, toughness and malleability are the important properties. The desired physical properties of any material are determined by the use to which it is to be put.

THE SLIDE RULE.

Angus Ballard.

Its Use in Every-Day Work—An Explanation of Its Uses and Advantages as a Time Saver.

(By Permission of "Mines and Minerals.")

FOR some reason, the logarithmic computing scale, or slide rule, as it has come to be termed, seems to be by most persons invested with a sort of mystery, or else regarded solely as a scientific curiosity, only to be appreciated by high priests in mathematical science, and so not worth consideration by men in whose work "practical mathematics" alone is needed.

As a matter of fact, to no class is this tool so useful as to the man of only "practical mathematics," once its uses and capabilities are understood. Nor is there anything either in the theory of its construction or the study or practice required for its successful use that is beyond the easy reach of any man with a working knowledge of arithmetic sufficient to handle the problems of his every-day work. It should be a sufficient indorsement of this appliance as a tool for every-day use to say that with it, in ordinary arithmetical problems, as much can be done in five minutes as with pencil in half an hour, and with far less liability to material error.

In the following paragraphs an attempt will be made to clear away some of the haze which seemingly prevents a due appreciation of the real simplicity and merits of the slide rule as a tool for every-day use.

Figs. 1 and 2 show two ordinary straightedges *A* and *B*, graduated on the lower and upper edges, respectively, the graduations on both being identical, as shown in Fig. 3, where the two are side by side. It will be noted that the graduations represent the numbers 1 to 100, those from 1 to 10 being equal in total length to those from 10 to 100, or the length 1 to 3 is equal to the length 10 to 30, and so on.

These lengths represent such properties of the numbers on the rules that, *when two or more lengths are added together, the total length represents the product of the several numbers corresponding to the separate lengths.*

Conversely, *the difference between two of these lengths represents the quotient of the number corresponding to the greater length, divided by the number corresponding to the lesser length.*

To add or to subtract these lengths is as simple an operation as to measure off a given distance from a point on one yardstick with another measure of the same kind, and it is done in exactly the same manner. Fig. 4 shows the operation. This figure serves equally well to illustrate the addition of the lengths *3* and *10*, or the subtraction of the length *10* from the length *30*. Or, in other words, Fig. 4 illustrates the method of multiplying two numbers, in this case *3* and *10*, or dividing one number, *30*, by another number, *10*.

In this operation, shown in Fig. 4 (in which for clearness all numbers except those used in the problem are omitted), the end of one of the rules *B*, or its index, as it is technically termed, is placed at the graduation on the rule *A* representing the number which is to be multiplied, and then reading along the rule *B*, on which the multiplier appears, until the graduation representing the multiplier is found; the number on the scale *A*, opposite the multiplier on the scale *B*, is the required product. The operation of division is performed in the reverse manner, for the convenience of reference, using Fig. 4 again. The graduation representing the divisor on the scale *B* is placed so as to coincide with the graduation representing the dividend on the other scale *A* (as *10* and *30* in the figure) and then noting at what graduation on the scale where the dividend is located, the end or index of the divisor scale comes, which graduation represents the quotient, or *3*, in the figure referred to.

Fig. 5 shows an elementary commercial form of slide rule (the finer graduations for purposes of clearness being omitted, as in Figs. 1 to 4), one of the rules *B* sliding within a groove in the rule *A* for convenience in keeping the rules adjacent and parallel. On examination of the rules in the position shown in Fig. 5, it will be noted that each number on the upper rule bears the same relation to the number indicated by the graduation immediately opposite, on the lower rule, that *3* does to *1*, or *30* to *10*; thus, *15* and *5* are found opposite

60 and *20*, *75* and *25*, and so on. Or, should the rules be so shifted relative to each other as to bring, say, the lengths *2* and *3* opposite each other, all the other numbers opposite each other would be found to bear the relation of 2 to 3; thus, *6* and *9* would be found opposite, *10* and *15*, *16* and *24*, *50* and *75*, and so on. This property of such rules will readily suggest an easy means of reducing, say, a given series of dimensions by a certain fractional part. These five figures illustrate the theory of design and the essential features of construction of the slide rule, and, if they are thoroughly understood, the ready use of this instrument for all ordinary multiplication and division is simply a matter of practice to acquire facility, as with any other mechanical tool.

It has been found advantageous, however, to add to the above simple form of slide rule several refinements of construction, with a view of making it a more convenient and useful instrument, until, as now perfected, the engineers' slide rule is usually made as shown in Fig. 6. But neither the principle of design nor the practice in use has been changed, and those to whom the foregoing description and operation are plain will have no difficulty in understanding the more elaborate device.

This instrument, as now generally made, consists of a principal graduated portion *M*, Fig. 6, usually made of boxwood, about 10 inches long, termed the *rule*, and having let into it in a suitable groove a smaller piece *N* similiarly graduated, and termed the *slide*. For the present, the reader is particularly referred to the graduations *A* and *B* on the upper side of the rule, ignoring, until the purpose of such is explained further on, the lower graduations A_1 and B_1. The graduations on the extreme edges have nothing to do with the rule as a calculating instrument, but are usually put there by the makers to increase the utility of the instrument by permitting its use for measuring or reference purposes.

It will be noticed that the rule shown in Fig. 6 carries an auxiliary piece *O*, being technically known as the *indicator*, or *runner*, which is a most important adjunct in the matter of convenient and rapid operation. This device in its most convenient form consists of a square metal frame, carrying a glass pane, on the under side of which is a hair line exactly at right angles to the axis of the rule. It is used for locating a particular graduation or number, as the product of two numbers, when it is desired to perform some additional operation upon them. In the use of the slide rule, so long as only the operations of multiplication or division are to be performed, it is not necessary to stop to read any of the results found until the final one is reached, bringing at each operation the line in the runner to identify each intermediate result as found in the manner shown in Fig. 4, and going on from this line as a new starting point. When intermediate operations of addition or subtraction are necessary, the numbers must be read with such precision as is possible, written out, and the sum or difference, as may be, accurately located again on the graduation of the rule for the further operations.

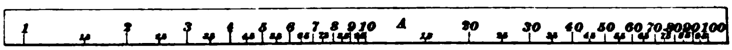


FIG. 1.

FIG. 2.

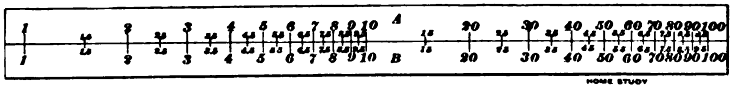



FIG. 3.

The graduated lengths usually read to *.02*, between *1* and *2*, to *.05* from *2* to *5*, to *.1* from *5* to *10*, to *.2* between *10* and *20*, to *.5* from *20* to *50*, and to units from *50* to *100*. Intermediate quantities or lengths can be estimated with sufficient precision for ordinary purposes. For purposes of clearness in the drawings, the finer graduations are omitted in all except Fig. 6.

A pertinent query, which will naturally arise, is, how are numbers, greater than the

graduations that the rule provides for, to be dealt with, as the graduations of the common rule only include numbers from *1* to *100?* Assume, for example, the problem of multiplying 245 by 216, and dividing the product by 940. It is plain that, so far as the *significant figures* of the result are concerned, any or all of these numbers might be multiplied or divided by 10, 100, 1,000, etc. without any effect. Or, if all were multiplied or divided by the same number, say 10, the actual result would not be changed at all. In other words, we know the result would be the same in all the cases expressed, thus:

$$\frac{245 \times 216}{940}, \quad \frac{2{,}450 \times 2{,}160}{9{,}400}, \quad \frac{24.5 \times 21.6}{94.0},$$
$$\frac{2.45 \times 2.16}{9.40}, \quad \frac{.245 \times .216}{.940},$$

and so on. Or, should we multiply a single one of the factors of the dividend by 10, or by 100, the final result would be 10 or 100 times too large, which would be corrected by moving the decimal point one or two places, as required.

It is this property of numbers which makes it both possible and easy to work with large numbers on a slide rule graduated only to 100. In working this problem with the slide rule, we will assume, for convenient manipulation of the instrument, that the two numbers to be multiplied are 2.45 and 21.6, respectively, and that the divisor is 9.4. To work the problem, place the index of the slide at *2.45* on the rule, adjust the runner till its hair line comes over *21.6* on the slide, and then, leaving the runner stationary, bring the slide graduation *9.4* to coincide with the line on the runner and note now at what graduation on the rule the index of the slide is found. It will be found, as nearly as can be read on the graduations, at *5.63*, but it will be recalled that one of these numbers, *21.6*, was 10 times too large, or was not reduced in the same proportion as the other two, and the result is, therefore, 10 times too great, or it really is *.563*±. To be more precise, it is *.562978*+, but *.563* is near enough for all ordinary purposes, and this result is read without difficulty on the graduations. The whole operation on the rule will not require 20 seconds. The only liability for material error lies in the possible failure of the operator to note where the decimal point in the final result should be located. In other words, the apparent result may be either correct, 10, 100, or 1,000, etc. times too great, or only $\frac{1}{10}$, $\frac{1}{100}$, or $\frac{1}{1000}$ of what it should be. There is little danger of any practical man making such a mistake, however. Suppose one were figuring the required cross-section of an airway in a mine, and the final result was found at the graduation *56* on the rule. One would hardly have to think twice to know whether this stood for .56, 5.6, 56, 560, or 5,600 square feet. As to reading the value of the graduations themselves, there is no more liability to, or excuse for, error than for reading the wrong figures on a tape line.

The operations of extracting the square and cube root of numbers are performed by the use of the lower set of graduations A_1 and B_1, shown in Fig. 6, and already referred to. It will be noticed in this figure that in this line the space *1* to *2*, or the length *2*, is exactly equal to the length *4* in the upper scale, *3* to *9*, and so on. Or, in other words, the numbers in the upper scale are the squares of the members of the numbers directly under them in the lower scale. To extract the square root of any number in the upper scale A, the runner is moved until the line cuts that number, and directly under that line, on the lower scale A_1, the corresponding square root will be found. The finding of a cube root is nearly as simple. For this operation withdraw the slide from the rule, reverse it end for end, place its index or figure *1* under the number the cube root of which is to be found, and read to the left on the reversed slide, along the graduations B, and to the right on the lower rule A_1, until some number is found at the same reading on both reversed slide graduations B and lower rule A_1, which number will be the desired cube root.

In the extraction of roots of numbers too great to be read directly on the rule, or numbers above *100* with the ordinary rule, particular care must be exercised in selecting the graduation on the rule from which to work. In these operations it will not do to select haphazard any graduation representing the significant figures of the number to be operated upon, as may be done in ordinary multiplication or division, above explained.

In extracting the square root of a number not represented on the graduations, say a number less than 1, or greater than 100, it must be first *multiplied or divided by a number itself a square*, say the square or the fourth power of 10, or 100, 10,000, etc., until some number is reached which appears on the graduations, and then proceed by using the runner as above directed. For example, if it is desired to ascertain the square root of

625, a number not found in the graduations, set the line of the runner at *6 25*, or $\frac{625}{100}$, *not 62.5*, and read on the lower scale B_1, under the line on the runner, *2.5*, which we know, by recalling that the square root of a number in the hundreds is always a number in the tens, represents 25, the required root.

Similarly, in extracting cube roots of numbers less or greater than the graduations directly represent, the number the root of which is desired must first be multiplied or divided by the third, sixth, ninth, etc. power of 10, that is, 1,000, 1,000,000, until a number is found which can be read direct on the upper scale of the rule. Assume, for instance, that the cube root of 5,000 is required, a number beyond the graduations. Dividing 5,000 by the cube of 10, or by 1,000, we have the number 5, which appears on the rule, and, by the reversed slide method above explained, we at once read on the lower part of the rule the figures 1.71±; but, as the cube root of thousands is tens, this root represents a number in the tens, or 17.1±. That this reading is precise enough for ordinary purposes will appear when it is stated that the cube of 17.1 is 5,000.211.

The time-saving qualities of this instrument can better be appreciated by giving some examples such as come up in every-day work, say the following:

Required, the capacity of a pump in cubic feet per hour, when the diameter of the piston is 10 inches, the length of the stroke 6 feet, and the number of strokes per minute 13.

The operation is represented by the following equation:

$$Q = \frac{10^2 \times .7854}{144} \times 6 \times 13 \times 60 = 2{,}550\pm.$$

To work this out with ordinary care with pencil will require 3 to 5 minutes. The time with a slide rule will not exceed 30 seconds.

Take the following practical problem:

If the pressure producing the ventilation of a mine be reduced from 11 pounds to 5 pounds per square foot, what quantity of air will circulate with the latter pressure if the former one produced a quantity of 120,000 cubic feet of air per minute?

This would be ascertained by the following equation, requiring for its solution nearly 5 minutes time with pencil.

$$Q = \sqrt{\frac{5}{11}} \times 120{,}000 = 80{,}904 \text{ cubic feet.}$$

The necessary operations involved would not require one minute at the most, were the slide rule used, and the result could be read with sufficient accuracy for all practical purposes.

There are in use some patterns of this class of instrument by which the last figure of any number up to one of six figures can be read direct, but these are wholly unnecessary for most work, besides being much more expensive and lacking in portability, though in their sphere they are invaluable as time and labor savers. The more common form shown herewith is sufficiently precise in its graduations for all ordinary work, is portable and simple, and once its capabilities and advantages are understood and appreciated, it will

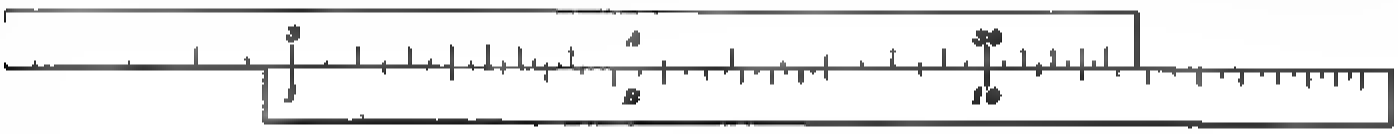


FIG. 4.

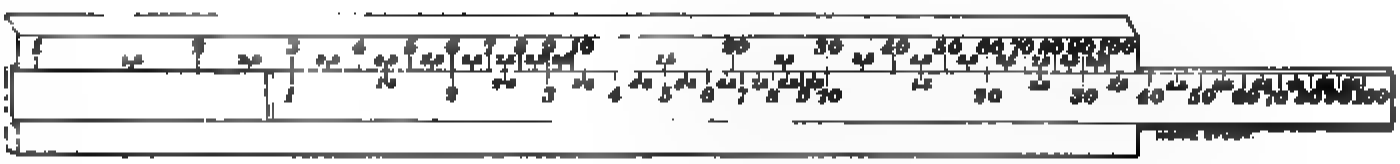


FIG. 5.

FIG. 6.

be as indispensable as the lead pencil and ordinary pocket rule have come to be in every-day work. Time is too valuable in these days of "high pressure" in engineering work for any of it to be unnecessarily wasted in the drudgery of the mechanical work of making figures on paper, when the same results can be arrived at with less liability of material error, less wear and tear, and in one-fourth the time, by the use of an instrument as simple as the familiar yardstick.

Numerous modifications and adaptations of the above simple form of slide rule are on the market, with which earthwork calculations, slag calculations, etc., can be greatly facilitated.

ELECTRIC FOUNTAINS.

L. S. Levy.

THEIR CONSTRUCTION AND OPERATION—MECHANISM OF THE COLOR SCREENS AND WATER VALVES—EXAMPLES OF THE DISPLAYS.

WITH the introduction of electrical displays on the stage, not many years ago, there opened a new era for electrical development, and we have today many electric appliances designed solely for producing spectacular effect. One of the most ingenious of these—the electric fountain—has gone through so rapid a series of improvements that it is now the principal attraction at illuminated displays, and a source of wonder and enjoyment to admiring thousands.

To the charm of the fountain's display by day, is added at night an aspect so weird and of such exquisite beauty as to suggest to the uninitiated the agency of the supernatural.

The illustration on this page is one of an electric fountain situated at the main entrance to Prospect Park, Brooklyn. This fountain represents in its particular line the highest development of electrical spectacular effects.

Fig. 1.

The view shown in Fig. 1 is illustrative of a group of beehives, with varicolored shafts of water. The tall shaft at the center has been properly termed a "geyser," and is

indeed representative of that beautiful manifestation of nature, with the added beauty that the electric light only can impart.

The successful combination of a colored beam of light with a directed stream or spray of water, whose hues are changed at will, is easily arranged. The principle underlying this combination is illustrated in Fig. 2. This sketch shows one method employed for illuminating the stream in an electric fountain. A transparent window g is placed immediately opposite the opening in the fountain nozzle n, and the rays from an arc lamp of special design are projected through the window and into the path of the jet j. A portion of the rays is reflected from the surface of the stream, producing an illumination of the falling drops. A quite different method of securing a diffusion of the rays through the stream was adopted in the design of the Brooklyn fountain.

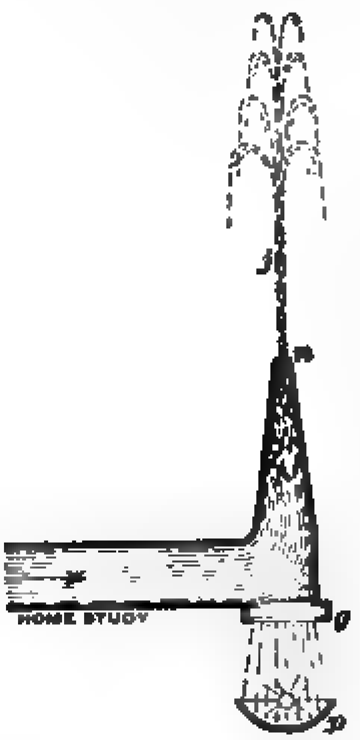


Fig. 2.

It is evident that an arc lamp of smaller candlepower will be required to illuminate the stream, if the rays are thrown directly upon the *surface* of the stream as it emerges from the nozzle. It possibly provides, in this instance, the only solution to the problem of illumination, as the display is not limited to that produced by solid streams.

The fountain, as shown, is located in the center of a large oval grass plot. The circular basin has a concrete foundation and a cement bottom, and has a diameter of about 120 feet. The actual diameter of the fountain proper—that part including the jets—is about 40 feet. Around the inner edge of the cement coping are arranged, at regular intervals, about eighty-eight 25-candlepower incandescent lamps, each enclosed in a waterproof globe. They are used for illumination at night when no display is in progress.

The fountain proper, in any case, consists of the jets and the illuminating funnels through which the colored rays are projected. Directly beneath the Brooklyn fountain is a large room, in which is installed the lamps, color-screen apparatus, and valves for the control of the water supply. A view of the interior of this room is shown in Fig. 3. In the ceiling, immediately above the lamp l, is shown the lower end of the aperture, or funnel, through which the light from the lamp is projected. This funnel extends a short distance above the surface of the water in the basin, as can be seen by referring to the illustration of the "Wheat Sheaves," Fig. 6. Surrounding the upper end of each of the funnels (there are nineteen), is a circular pipe, pierced by a number of holes, through which the water is projected to form the various combinations of light and color. Protruding from the center of each funnel is a pipe of about 1¼ inches diameter, which assists in the production of the "Fan," Fig. 5, and other pleasing effects.

Below each of the funnels a powerful arc

Fig. 3.

lamp is placed. This lamp is of the focusing-projection pattern, and is provided with a parabolic reflector, in order to direct the rays in parallel lines. The lamp requires for its operation a current of 40 amperes, maintained by an E. M. F. of 50 volts.

The lamp, used as it stands, can only impart a white illumination of intense brightness to the stream. For the purposes

of color variation, color disks are provided, which are mounted so that they can be brought into the path of the light rays. This detail of construction has been very ingeniously devised, as will be evident from

FIG. 4.

Fig. 3. The screens, bearing diaphragms $a\,a$ of various colors, are pivoted about a common center b, and when swung through an angle of nearly 90° are directly beneath the funnel, intercepting and lending color to the rays from the lamp l. There is one opaque screen provided for the purpose of darkening the funnel if, at any time during a display, it is necessary to effect a combination in which all the funnels are not used.

It is evident that, to make the operation of the fountain as simple as possible, the apparatus by which the hydraulic mechanism is operated, and the electric lights controlled, must be managed by as few persons as is consistent with good results.

Several very ingenious appliances, which almost assume the proportions of independent systems, have been introduced in the installation of the fountain under description. The successful operation of the color screens, in conjunction with the various combinations, determines, in a measure, the value and efficiency of the fountain.

It will be gathered, from what has been said, that a system which provides for a concentration of the controlling mechanism has been adopted in connection with the fountain illustrated in this article.

The principal part of the system lies in the mechanism that operates the color screens directly, and this, in the case at hand, is made up of a number of cylinders, the pistons of which are connected to the arms of the color screens, and are operated by compressed air, derived from a special compressor, electrically driven.

The control of the air cylinders, illustrated at c, Fig. 3, is effected by means of valves controlled by push buttons. It is evident that, to effect the various combinations, numerous buttons, systematically arranged, must be provided and installed in the most convenient position. The manner of their

FIG. 5.

arrangement can be seen by referring to Fig. 4. Here the buttons constitute a switchboard of no mean proportions and complexity.

As there are eight color screens to each funnel, a separate cable, composed of sixteen No. 24 B. & S. wires, runs from each set of valves to a set of buttons placed on the color board, over the hydraulic operating valves in the operating room, as shown in Fig. 4. A common return wire is used for all the magnets. Each of these compound buttons consists of sixteen separate pushes in two rows, each button of the top row being

colored and corresponding with its respective color disk, which is operated when the button is pushed. In the lower row, the buttons are all white, and each acts as a release button for the colored button below which it is located. An ordinary open-circuit battery is used to operate these electro-pneumatic valves. When the release button is pushed, the air cylinder is exhausted by reason of its connection with the atmosphere, and the disk is automatically returned to its normal position by means of a barrel spring. The carrying levers of each of the color disks are mounted on ball bearings, thus greatly facilitating their operation.

At *w*, *w*, Fig. 4, will be seen two windows, which are located in the side wall of the fountain basin, keeping the fountain in sight of the operator at all times. This arrangement is an appreciable factor in the speed with which the fountain can be operated, as no dependence is placed on the transmission of instructions; so that it is free from the mistakes which are bound to occur in the best regulated systems wherein the operator cannot see the fountain.

The concentration of the entire operating mechanism at one point has made it possible to operate the fountain with only two men —one being located on a platform in front of the valves and color buttons, and the other having charge of the lamps beneath the basin. The man at the controlling appliances simply raises the levers to effect any suitable water display, after having pushed the necessary color buttons for the different funnels.

This change of views can be made so rapidly that the fountain may be used for displays of a particular character. For instance the effect produced in the display pictured at Fig. 5, while in itself a beautiful combination, and of magnificent appearance at night, when colored, would be enhanced if the design were some such favorite theme as that of our national emblem.

In excellent keeping with so grand a sight, the change to that in Fig. 6 could be rapidly effected, and a representation given of the prime product of our great West, illuminated in its truly beautiful color—emblematic of national integrity and of the vast resources of the Republic.

Fig. 6.

HOW TO DRAW A STRAIGHT LINE.

George A. Goodenough.

EUCLID'S STRAIGHT-LINE POSTULATE—EVANS'S STRAIGHT-LINE MOTION—THE THEORY OF INVERSION—PEAUCELLIER'S EXACT MECHANISM.

EUCLID'S three postulates are: "I. A right line may be drawn from any one point to any other point." "II. A terminated right line may be produced to any length in a right line." "III. A circle may be described from any center, and with a radius equal to any finite right line." These being granted, we can erect perpendiculars, bisect angles, construct triangles and polygons, and solve a multitude of other geometrical problems. But why does Euclid ask us to grant so simple a thing as the drawing of a straight line? Because, so far as Euclid knew, there was no way of actually performing the feat.

Of our ability to draw a circle there can be no doubt. If we take any rigid bar with two fixed sharp points and rotate the bar about one point as a center, the other point will describe a circle. Of course, the mark made by the point will have a certain breadth, and to just that extent deviates from the strict definition of a line; but either boundary of the mark will be a mathematical line and will also be a circle. If, however, we attempt to draw a straight line between two points by means of a ruler and pen or pencil, we have no assurance that even the boundary of the mark made is straight; in fact, we may be pretty sure that it is not straight. At best the edge of the ruler is but an imperfect copy of a straight line, and we are thus making use of the thing we are trying to draw. Any effort to draw a straight line by means of a ruler is, therefore, merely a begging of the question.

Granting, then, that we cannot draw a straight line by means of the ruler or straightedge, the question arises whether there is any other way in which we can draw an accurate straight line in the same sense that we can draw an accurate circle. This question has demanded more or less attention from engineers and mathematicians since the days of Watt; but it was as late as 1864 that the first exact method of drawing a straight line was discovered by M. Peaucellier, a French engineer officer.

Previous to Peaucellier's invention, there had been invented a large number of so called "parallel motions"—mechanisms, designed to guide a moving point in a straight line. In some of these motions, the whole path of the point is a closed curve, the portion utilized approximating more or less closely to a straight line; in other motions, the path of the guided point is really a straight line in the same sense that the edge of a ruler is straight. It will be worth while to examine one of these last mentioned motions, and for this purpose we select the well known Evans mechanism, Fig. 1. One end of a lever b is guided in a rectilinear path by the block a, which slides in the guides e, e. The middle point E of the lever is jointed to a link c, and is thereby constrained to move in the circular path EE'. It can easily be shown that, if the joint G moves in an exact straight

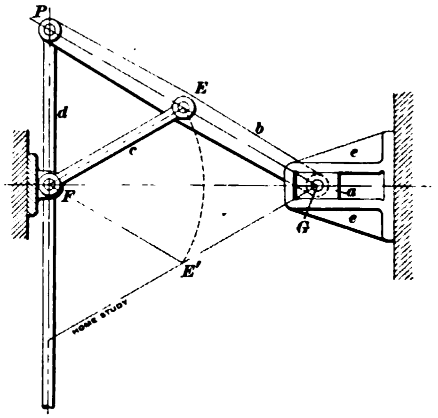


FIG. 1.

line, the point P ($PE = GE$) must also move in a straight line. For practical purposes, the motion is all that could be desired; but it is easily seen that, so far as the solution of the problem of drawing an exact straight line is concerned, it begs the question. In order that P shall move in a straight line, G must also move in a straight line, and this must be brought about by making the guides e, e with exact plane faces; thus the drawing of a straight line is involved in the construction of the mechanism.

We pass now to Peaucellier's mechanism—one which actually does draw a straight line. Before entering into an explanation of the mechanism, however, it is necessary to give an outline of a beautiful geometric theory, called the *theory of inversion*, upon which the action of the Peaucellier motion depends.

Suppose we have a circle c, Fig. 2, with a center at O, and a radius OR. Through any point A we draw a radial line OA and produce it indefinitely; and on this line we locate a second point A' such that the product $OA \times OA'$ is equal to the square of the radius; that is, $OA \times OA' = \overline{OR}^2$. Then, with respect to the circle c, the point A' is said to be the *inverse* of the point A; and, conversely, A is the inverse of A'. It is readily seen that every point within the circle has an inverse point outside of the circle, and vice versa. If we take the points B, C, D, etc. of a curve m, and find their inverse points B', C', D', etc., we locate a second curve m', which is the inverse of the original curve m with respect to the circle c.

From the expression $OA \times OA' = \overline{OR}^2$, we have $OA' = \frac{\overline{OR}^2}{OA}$. This shows that, if we move the point A along the radius toward the center O, the denominator OA of the fraction $\frac{\overline{OR}^2}{OA}$ decreases and the distance OA' increases; therefore, as A moves toward O, the inverse point A' moves in the opposite direction. When A approaches very near to O, it is clear that A' must be at a very great distance, and finally, if we conceive A to coincide with O, A' must lie at an infinite distance. This we express by saying that *the inverse of the center O is at infinity*.

Referring now to Fig. 3, suppose we have a circle m, which is to be inverted with respect to the circle of inversion c. We wish to determine the character of the inverse curve m'. By actually plotting the inverse points of several points of m, as A, B, E, F, M, N, etc., we readily find that the inverse curve is a second circle. A formal proof of this fact is quite simple, and involves only the most elementary principles of plane geometry.

Through the center O, we draw any line cutting the circle m in the points E and F, and on this line we locate the inverse points E' and F'. A second line through O cuts m in M and N, and the inverse points are M' and N'. Let us now draw, from O, the two tangents to the circle m, and locate the inverse points A' and B' of the points of tangency A and B. Now, it is a well known property of the circle that if, from any external point, as O, a line is drawn cutting the circle in two points, as E and F, the product $OE \times OF$ is constant and equal to the square of the tangent distance OA. We have then

$$OE \times OF = \overline{OA}^2,$$

and likewise $OM \times ON = \overline{OA}^2$.

But, from the definition of the process of inversion,

$$OE \times OE' = \overline{OR}^2,$$

or,

$$OE = \frac{\overline{OR}^2}{OE'}.$$

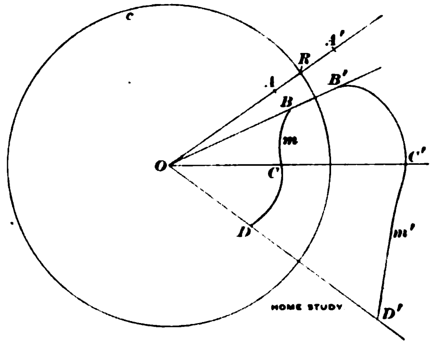


FIG. 2.

Likewise,

$$OF = \frac{\overline{OR}^2}{OF'},\ OM = \frac{\overline{OR}^2}{OM'},\ ON = \frac{\overline{OR}^2}{ON'},$$

where OR denotes, as in Fig. 2, the radius of the circle c.

Multiplying,

$$OE \times OF = \frac{\overline{OR}^2}{OE'} \times \frac{\overline{OR}^2}{OF'} = \frac{\overline{OR}^4}{OE' \times OF'} = \overline{OA}^2;$$

or,

$$OE' \times OF' = \frac{\overline{OR}^4}{\overline{OA}^2}.$$

In the same manner, $OM' \times ON' = \frac{\overline{OR}^4}{\overline{OA}^2}$.

But,

$$\frac{\overline{OR}^2}{OA} = OA',\ \text{and}\ \frac{\overline{OR}^4}{\overline{OA}^2} = \overline{OA'}^2;$$

hence, $OE' \times OF' = \overline{OA'}^2$,

and $OM' \times ON' = \overline{OA'}^2$.

These equations show that, if we draw from O any line cutting the inverse curve m' in two points, the product of the distances from O to these points is constant, and equal to the square of OA', the tangent distance. It follows from this that the inverse curve m' is a circle, and we have the following important proposition: *the inverse of a circle is a second circle.*

It is interesting to note the relative positions of the circles under different conditions. It is readily seen that, if one circle cuts the circle of inversion c in two points, the inverse circle will cut it in the same points. If, as in Fig. 3, the original circle lies within c, but does not include the center O, the inverse circle will lie wholly outside of c; but, if the original circle m encloses the center O, the inverse circle will also include the center O. If the circle m passes through the center O, we have a case of special importance. The line joining the centers O and S of the circles c and m cuts the circle m in the points P and Q, the extremities of a diameter, and the inverse points are P' and Q'. Now, if the point P is left in its original position, and the point Q is moved nearer and nearer the center O, thus increasing the diameter of the circle m, the inverse point P' will evidently remain in its original position P', but the inverse point Q' will move farther and farther away, and the arc $A' P' B'$ will become flatter and flatter. Finally, when the point Q coincides with the center O, that is, when the circle m takes the position n shown dotted, the point Q' will lie at an infinite distance, and the inverse circle m' becomes the straight line n', passing through the inverse point P' at right angles to OP'. We have, therefore,

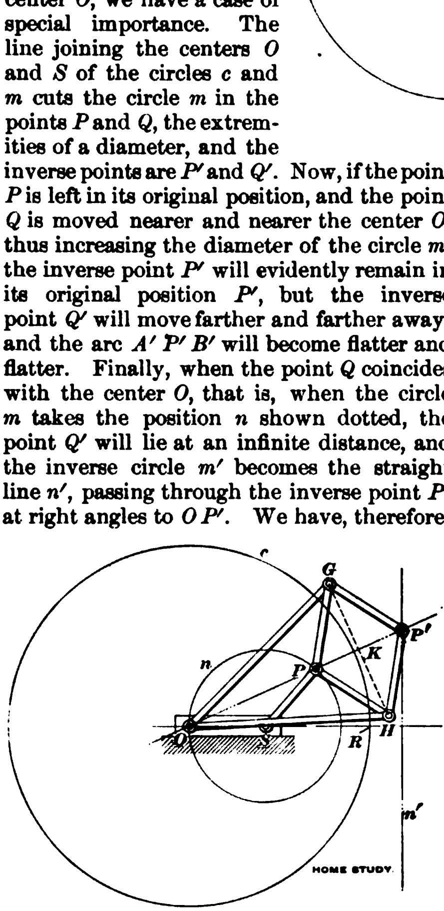


FIG. 4.

a second important proposition: *the inverse of a circle which passes through the center of inversion is a straight line.* This statement does not contradict the previous more general proposition, for we may consider a straight line to be simply a circle with its center at an infinite distance.

We have now the connection between the theory of inversion and the drawing of a straight line. We have seen that it is possible

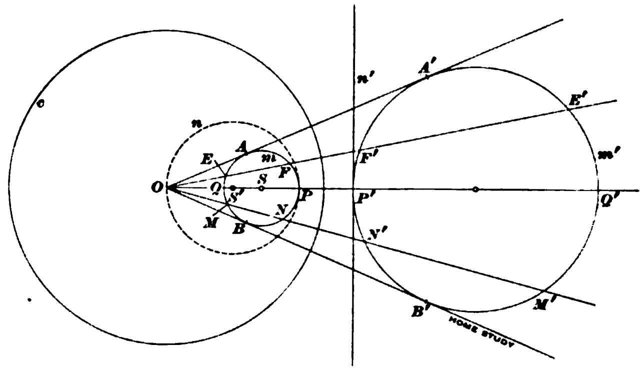


FIG. 3.

to draw an exact circle; hence, if we can devise a mechanism that will draw the inverse of a circle, it will draw an exact straight line when the circle is made to pass through the center of inversion. This is accomplished perfectly by Peaucellier's remarkable mechanism. The following is a brief description of the mechanism: Four links PG, GP', $P'H$, and HP, Fig. 4, of equal length, are jointed to form a rhombus. One corner P of the rhombus is joined to a fixed point S by the link PS, while the two opposite corners G and H are joined by links GO and HO to a second fixed point O.

The point P is forced to describe a circle about S as a center, and with PS as a radius, and the point P' at the same time describes the inverse of this circle. This is readily proved as follows: From the symmetry of the mechanism it is clear that the three points O, P, and P' must always lie in one straight line. Connect G and H; because $PHP'G$ is a rhombus, GH is perpendicular to PP', and $PK = P'K$.

Now, $\quad OP = OK - KP,$

and $\quad OP' = OK + KP' = OK + KP.$

Multiplying these two equations,

$$OP \times OP' = (OK - KP)(OK + KP) = \overline{OK}^2 - \overline{KP}^2.$$

From the right-angled triangles OGK and PGK, $\quad \overline{OK}^2 = \overline{OG}^2 - \overline{GK}^2,$

and $\quad \overline{KP}^2 = \overline{PG}^2 - \overline{GK}^2.$

Subtracting,

$$\overline{OK}^2 - \overline{KP}^2 = \overline{OG}^2 - \overline{PG}^2;$$

hence, $\quad OP \times OP' = \overline{OG}^2 - \overline{PG}^2.$

Now, since OG and PG are invariable,

the links being rigid, the product $OP \times OP'$ is a constant quantity, and P' is the inverse of P for any position of the mechanism, the point O being the center of inversion. If the circle described by P does not pass through O, the inverse curve described by P' will be the arc of a circle. To make the point P' describe a straight line, it is only necessary to make the circle described by P pass through O, which is readily accomplished by making the length of the link PS exactly equal to the distance between the points O and S. When the mechanism is thus constructed, the point P' must describe a theoretically exact straight line.

It will be observed that nothing in the construction of the Peaucellier mechanism vitiates the exactness of the straight line. Theoretically, at least, the links can be given exactly the required lengths; and the pins of the joints, being cylinders of circular cross-section, can be made exact, because of our ability to draw a perfect circle. The mechanism is, therefore, a complete answer to the question—how can we draw a straight line?

Since Peaucellier's invention, several other exact straight-line motions have been discovered, most of which, however, are more or less closely related to the original.

HIGH RAILROAD SPEEDS.*

H. Rolfe.

HOW THE TRACTIVE FORCE AND HORSEPOWER VARY WITH THE SPEED—DYNAMOMETER V. INDICATOR—SOME POINTS OF DESIGN.

CLOSELY connected with the question of engine capacity, is that of *train resistance*. Now, it has yet to be proved that the total resistance of the whole train (including engine and tender) increases with the speed, although, of course, the horsepower exerted by the engine does. The dynamometer and the indicator seem to antagonize each other on this point. The tractive force exerted by the engine is a measure of the resistance which it has to overcome, and this tractive force varies with the mean effective pressure, or M. E. P., in the cylinders. But an inspection of any diagram proves that the M. E. P. is less at high than at low speeds. The figure on next page shows four cards, taken from the same engine when running at different speeds. Data concerning these diagrams are given in the above table.

Card.	Speed. Miles per Hour.	Boiler Pressure. Lb. per sq. in.	Throttle.	Cut-Off. Inches.	M. E. P. Lb. per sq. in.	Horsepower Developed.	Tractive Force Exerted.
A	35	172	$\frac{3}{16}$ Open	7	77	780	8,357
B	56	178	Full	8	60	972	6,509
C	68	175	Full	8	49	964	5,360
D	73	135	$\frac{1}{4}$ Open	5	29	613	3,150

It will be seen that the horsepower developed increases with the increase of speed, up to 56 miles per hour, decreases very slightly as the speed increases to 68 miles per hour, and then decreases rapidly. This sudden drop from 964 to 613 horsepower is surprising, being altogether at variance with what we should naturally look for. The M. E. P. at the highest speed is, however, about as much as we should expect to get, comparing the boiler pressure, cut-off, and throttle opening with those of the other cards.

The horsepower is obtained as follows:

Let v = speed of train in miles per hour;
a = area of piston in square inches;
s = length of stroke, in feet;
d = diameter of drivers, in feet;
N = number of revolutions per minute;
H. P. = horsepower developed;
T. F. = mean tractive force exerted.

We then have

$$N = \frac{v \times 5,280}{60 \times 3.1416\, d}. \qquad (1)$$

$$\text{H. P.} = 2\left(\frac{N \times 2s \times \text{M. E. P.} \times a}{33,000}\right). \qquad (2)$$

* *Continued from November, 1898, Number.*

$$\text{T. F.} = \frac{\text{H. P.} \times 33{,}000 \times 60}{v \times 5{,}280}. \qquad (3)$$

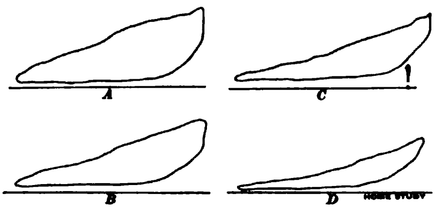
For card *A*

$$N = \frac{35 \times 5{,}280}{60 \times 3.1416 \times 6} = 164.$$

$$\text{H. P.} = 2\left(\frac{164 \times 4 \times 77 \times 254.5}{33{,}000}\right) = 780, \text{ nearly.}$$

$$\text{T. F.} = \frac{780 \times 33{,}000 \times 60}{35 \times 5{,}280} = 8{,}357 \text{ pounds.}$$

The tractive force for the other speeds is found in a similar manner. It is then seen that although the horsepower developed is *greater* the higher the speed of the train, the tractive force is *less;* that is, less effort is required to move the train—in other words, the cards prove that resistance *decreases* as the speed *increases.* It is natural to expect the



horsepower to increase as the speed increases—that is, as the distance covered, per unit of time, increases. That it does not increase, after a certain speed is reached, seems to prove that for higher speeds the resistance not only ceases to increase but actually decreases.

This fact once established, it is next in order to look around for a rational explanation of it. Now, at any given speed, the only resistances to the continued motion of the train at that speed are due to friction of two kinds, namely, mechanical and atmospheric. It is well known that between solids, kinetic friction, or friction of motion, is always less than static friction, or friction of rest. So far, then, theory does not conflict with what the indicator card tells us. Regarding atmospheric friction, however, all old beliefs are at variance with what practice appears to prove, for it had always been assumed that the resistance offered by the air to a body moving in it increased not only *with* the speed of motion but as the *square* of that speed. The latter part of this belief has now been abandoned.

It may be argued that the dynamometer seems to oppose the results just quoted. It must be remembered, however, that this instrument gives the resistance of only the weight behind the tender, whereas the indicator measures the work expended on the whole train—engine, tender, and cars. It is easy to say that as the resistance of the cars increases, so also must that of the engine and tender; but this is just what we want to know. The card *D* does certainly seem rather slim, compared with the others. The question is: Is it a true index to the full amount of steam admitted to the cylinder? It is just possible that at high speeds, the inertia of the indicator piston and spring causes the curve to be a little low throughout; the motion being so rapid that the steam does not have time to get the piston up as high as the steam pressure warrants. We have no information as to whether the speed of the train was increasing when the cards were taken, and this has an important bearing on the subject. It makes a considerable difference whether the engine is just holding her own or is *increasing* the speed of the train. In the latter case the indicator will show at once the extra power expended. It is possible that card *D* was taken when entering on a down grade, or when dropping speed somewhat; or the others may have been taken when the speed of the train was being increased—however slightly. For such readings to be reliable, the speeds should have been just maintained, neither increase nor decrease taking place. To return to the question of a lesser engine resistance at high speeds: there are two arguments in favor of this that occur to the writer, which he has never seen put forward before. *First*, the average pressure on the piston being less, there is less frictional resistance all around—less crosshead friction, less friction at the crank and wristpins, and also, it seems natural to suppose, less friction in the cylinder itself. On the other hand, there is a greater steam-chest pressure, owing to the flow therefrom being more restricted; as a result of this, and of there being also a lighter exhaust acting on the cavity of the valve, the valve friction will be somewhat greater. Again, at high speeds the cut-off and the exhaust closure are both earlier, and therefore there is greater compression; this throws a strain on to the wristpins, and crankpins, when nearing the centers, and thus sets up increased friction. This is aggravated if there is too much lead or if there is any inside lap. *Second*, the faster the speed, the straighter the path of the engine. Not only is its inertia, as a whole, greater, but the rotary motion of the wheels, cranks, main and side rods, etc. produce a gyrostatic motion which tends to oppose any alteration of the planes of rotation, the same being

true, in a lesser degree, of the tender. The effect of all this is to keep the engine in a straighter and truer path ; there is therefore less flange friction between the wheels and rails. Also, there being less "nosing" and less oscillation on the springs, the engine keeps a straighter path, as a whole, and therefore ought to consume less power. However this may be, there the cards are ; and, so far as we remember, the higher the speed, the less tractive power the card *always* shows. The points to be observed in designing high-speed locomotives may be briefly summarized as follows:

1. Carry a high pressure—say 200 pounds per square inch. There is much to be said both for and against excessive pressures. In France they are carrying 220 and 225 pounds on their compounds. A good many designers, however, think that 180 pounds is high enough for single engines, and certainly good work can be done with this pressure, making up the margin in the cylinder volume. If the boiler is equal to supplying any amount of steam that may be called for, and maintain the full pressure of 180, then there won't be much to complain of in this direction. Very high pressures, of course, cause a little extra wear and tear, but when it is simply a matter of high speed, this point must be waived and therefore a pressure of 200 pounds may be adopted.

2. Design the cylinders to suit the load, average gradients, and required speed, working on the basis of the necessary M. E. P. at desired cut-off.

3. Provide liberal exhaust passages ; give the valve inside clearance, and not more than about $\frac{1}{16}$ inch lead in running position. Employ a long valve travel, thus securing a quick motion of the valve and a greater port opening for a given piston displacement. In view of the fact that piston valves wear longer and do not absorb so much power in moving them, adopt them if practicable, especially with very high pressures, for the drag on a slide valve is always considerable, even when "balanced."

4. Keep the weight of the reciprocating parts down as low as possible, as the stress on the rails due to the "excess balance" increases as the square of the speed ; and the vertical lift when on top quarters is also correspondingly great, this diminution of rail pressure aggravating the tendency to slip, and therefore militating against extreme speeds. Also, keep down the weight of *all other* parts ; the wheel centers, as generally designed, offer a pretty good field for cutting down weight.

5. All the weight thus saved, put into the boiler, and thus have a reserve to fall back upon when encountering an upgrade in dirty weather, in which contingency a single engine, if loaded up to its capacity, generally loses a lot of steam through slipping.

6. Use a large wheel, and obtain the tractive power by adopting a long stroke.

7. Design the boiler to suit the intended fuel. Use as large a boiler as weight will allow. Since the capacity of the engine is, after all, a question of steam supply, anything that will economize the use of the latter will increase the power of the engine, and consequently, the speed. Use, therefore, as small clearance space as possible, and, with given space, keep the cooling surface down as low as practicable.

The desirability of minimizing the weight of the reciprocating parts is due to its being impossible to balance them properly in the wheels—as locomotives are now arranged.

The main and side rods should be as light as possible, for the higher the speed the more these parts are strained, thus calling for extra strength, which—if the design is adhered to—means extra weight also. This weight increases the centrifugal loading, and is, therefore, in itself, an element of weakness, as compared with the case of stationary parts. The two concomitant elements of strength and lightness are attained by channeling the rods, and there is not much room for further saving of weight in these parts as turned out by our best designers ; something, it is true, could be saved by using bushed ends, but it would be of scarcely any value as regards centrifugal stresses. The reciprocating weight could be reduced, however, by bushing the front end of the main rod, further lightness being secured by using hollow piston rods, dished steel pistons, and crossheads of rather more esthetic design than is generally met with. A further lightening all around would also result from a freer use of steel castings, which have, so far, been more largely employed in England than here ; to this is due the fact of their engines being so powerful for their weight.

In these articles, attention has been drawn in a general way to the many aspects in which the question of high train speeds presents itself, and it has been briefly shown how, in order to carry through a severe schedule satisfactorily, there must be vigilance and cooperation on the part of all concerned—not an emulation of the methods of politicians, who try to get the world along by pulling in opposite directions.

(*The End.*)

SETTING CORLISS VALVES.

W. Sherwood Porter.

LAP AND LEAD—TABLE OF LAP—TESTING WRISTPLATE MOTION—SETTING THE VALVES—THE ECCENTRIC—THE GOVERNOR—TEST WITH a STEAM INDICATOR.

IN THE following directions for setting Corliss valves, it is taken for granted that the reader is more or less familiar with the details of the Corliss valve mechanism as described in HOME STUDY MAGAZINE, October, 1898, article entitled "The Corliss Valve Gear."

In any valve gear, the motion of which is derived from the action of an eccentric set at 90° ahead of the crank, the crank will be on its center when the eccentric is at half throw. The eccentric will then arrive at its greatest throw, and the opening motion of the valve will cease when the crank is at half stroke. Now, with detaching gears, such as that of the Corliss engine, the releasing mechanism must operate, if at all, before this point in the eccentric travel is reached, otherwise the valve will begin to close positively, and at a speed governed by the eccentric on its return stroke. The Corliss valve gear, when properly constructed, closes the valve positively, before the end of the stroke, in case the trip does not act or the dashpot fails to close it; this fact does not seem to be generally known. It follows then, that, when the detaching mechanism does not operate, a steam valve set edge to edge with the port opening is closed at the moment the piston reaches the end of its stroke. The exhaust valve on that end of the cylinder opens at the same moment, and there is a tendency to blow through. On the other end of the cylinder the exhaust valve closes and the steam valve opens, also at precisely the same moment, giving the steam another chance to blow through. It is essential, then, that the steam valve shall have a definite advance in its closing movements, relative to the opening of the exhaust valve, in order that it may have a safe working lap before the exhaust port is opened, and that it may not open until after the exhaust valve has closed. The exhaust valve must also have an advance relative to the piston movement, in order that there may be prompt release, and that they shall close—on the end towards which the piston is moving—before it arrives at the end of its stroke. This is necessary to produce sufficient compression to check the motion of the reciprocating parts of the engine.

By setting the eccentric at an angle of more than 90° ahead of the crank, we get an earlier opening and an earlier closing of all the valves, relative to the piston motion. Unfortunately, however, the same amount of lead is not wanted for all the valves, more lead being required on the exhaust valves, when they close for compression, than is wanted on the steam valves. But this does not help us to get the steam valve closed previous to the opening of the exhaust valve, nor the exhaust closed before admission of steam. The effect, then, of lead, as derived from the advance of the eccentric to an angle of more than 90° from the crank, is to hasten both the opening and the closing of all the valves, as regards the motion of the piston. Therefore it hastens cut-off and limits its range.

The effect of lap on a valve is to hasten its closing and retard its opening. Here again, cut-off is hastened and its range limited. From this it will be seen that there are conflicting conditions in the setting of valves when a single wristplate is used, between which a compromise must be effected. No definite rule can be given by which the amount of lap for a valve can be determined. It depends somewhat on the design of the valve and its relative proportions; also upon the conditions under which the engine is to work. In all cases the lap increases with the size of the cylinder. The table on the following page furnishes a fairly reliable guide as to the amount of lap to be given to valves on different sizes of engines:

In Fig. 1 are shown the various parts of a Corliss valve gear and their relation to one another: *A* is the head end of the cylinder; *B* is the crank end; *w* is the wristplate; *d*, *e* are the steam rods; *f*, *g*, the exhaust rods; *h*, *i*, the dashpot rods; *j*, *k*, the dashpots; *c*, the carrier rod; *a*, *b*, the reach rods; *m*, the reach-rod lever; *o*, the eccentric rod; *n*, the carrier arm; *p*, the eccentric; and *l*, the regulating gag pot.

A method of centering the wristplate is

illustrated by the plumb-line $x\,y$ let fall from the hand. Usually, however, it is not necessary to resort to this scheme; in most cases there will be found three marks as at c, b, d, Fig. 2, on the wristplate bracket and another mark, a on the hub of the wristplate. These will enable us to do our centering. The marks are so located that a is opposite b when the wristplate is at its center of motion. At the two extremes of motion a is opposite either c or d.

It may be well, however, to test these marks, or rather to see that the eccentric and carrier rods have proper adjustment relative to the motion of the wristplate. To do this we rotate the eccentric p on its shaft, having the eccentric rod o connected and the carrier rod c hooked over on the wristplate; then notice whether or not the carrier arm is equidistant, in its extreme travel each way, from the plumb-line $x\,y$ let fall through the center of its pin. If it is not, we will make it so by adjusting the length of the eccentric rod o. Then we see if the mark on the wristplate hub agrees with those on the bracket at full throw each way; if not, the remedy is to change the length of the carrier rod c until there is perfect agreement.

Having tested the marks to our satisfaction, we will temporarily secure the wristplate w at its center of motion.

Upon removing the back bonnets, or caps, from the ends of the valve chambers so that the rear ends of the valves are exposed, we find a mark on each face of the valve ports, showing the location and width of the port openings in relation to the cylinder. Upon the ends of the valves are marks which are in line with the opening edges of the valves. See Figs. 3 and 4. Possibly, in some of the older types of engines, these may be missing; in such a case, the valves will have to be removed to locate the port openings and the opening edges of the valves. Consulting the above table, we find the lap for the steam valves, and the opening to be given the exhaust valves, for our particular case. Then, by lengthening or shortening the rods leading from the wristplate to the valve arms, we bring the opening edges of the valves to positions corresponding with our predetermined lap or opening. While making these adjustments, it is, of course, essential that the steam latch shall be hooked on the stud. If a record is kept of how much the valve moves at one turn of the

A

Fig. 1.

TABLE OF STEAM LAP AND EXHAUST OPENING.

Diameter of Cylinder. Inches.	Lap for Steam Valve. Inches.	Exhaust-Valve Opening. Inches.	Diameter of Cylinder. Inches.	Lap for Steam Valve. Inches.	Exhaust-Valve Opening. Inches.
12	1/4	1/32	30	1/2	1/8
14	5/16	1/32	32	1/2	1/8
16	5/16	1/32	34	1/2	1/8
18	3/8	1/16	36	1/2	1/8
20	3/8	1/16	38	9/16	5/32
22	3/8	1/16	40	9/16	5/32
24	7/16	3/32	42	9/16	5/32
26	7/16	3/32	44	5/8	3/16
28	7/16	3/32	46	5/8	3/16

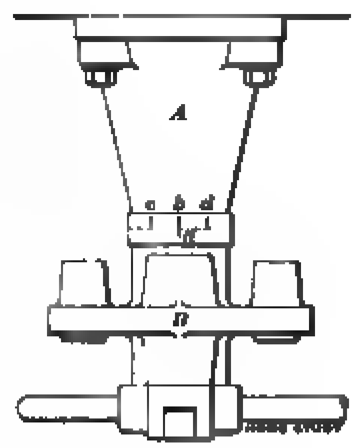


Fig. 2.

adjusting nut on the rod, future adjustments may be made without necessitating the removal of the bonnets.

All the valves are now supposed to be in their proper positions when the wristplate is at its center of movements. The section shown in Fig. 5 gives this position, except that a' is supposed to be unhooked and to stand in a position of full closure. The next thing in order is to locate the eccentric at the proper angle ahead of the crank to give sufficient lead. First, we will set the engine exactly on its center; and with the carrier rod hooked on the wristplate stud, revolve the eccentric on the shaft, in the direction in which the engine is to run, until it is at an angle greater than 90° ahead of the crank, or until the steam valve on the end at which the piston stands is just beginning to open, say, $\frac{1}{32}$ of an inch open. In this position the eccentric must be secured to the shaft. Then we turn the engine to the other center and see if the steam valve on the other end has the same amount of opening as the other had. It should and will have the same amount, if all our adjustments have been carefully made.

We will now turn our attention to the governing apparatus. The function of a governor is to act in accord with every variation in load, and to so limit the quantity of steam admitted to the cylinder as to overcome the resistance of the load, and to maintain a uniform speed of rotation of the engine shaft. For the purpose of adjustment, we block the governor so that the balls stand in the position they would assume at normal speed (about mid position), and fasten the reach-rod lever m at right angles to a line $M\ N$, Fig. 1, midway between the reach rods. Now we will turn the engine to the point at which cut-off should occur (usually about $\frac{1}{4}$ stroke), and adjust the reach rod for that end, so the valve will trip at that point. The valve and the reach rod for the other end of the cylinder must be treated in a like manner. To determine the point of $\frac{1}{4}$ stroke, we mark the length of stroke on the crosshead guides and measure off $\frac{1}{4}$ of this from each end. After a few trials, partially rotating the engine back and forth, at the same time making careful adjustments of the reach rods, we can make it cut off at exactly similar points for each end. It is well, now, to lower the governor to the lowest position, and observe that the cut-off mechanism does not work, but allows steam to be taken during the full stroke of the piston.

Care must be taken, in making adjustments of a machine like this, that we do not overlook even the smallest detail. For instance, we must have the dashpot rods of such a length that the steam arm will be in a position where the latch will surely hook

FIG. 3.

when the dashpot plunger is home; that is, the latch stud should be midway between the latch die and the closing shoulder when the plunger is at the bottom. The object of the regulator gag pot l is to prevent over sensitiveness of the governor. To increase the sensitiveness, remove one screw from the gag pot piston.

Were there any doubt now that our engine

FIG. 4.

would work at the best steam economy, we should test our work by means of a steam indicator. Such a test is the most approved method known by which a line may be had on the working of an engine, notwithstanding

the fact that the indicator is hooted at by many supposedly good engineers. A man who will not use an indicator is not fit to have charge of an engine.

Remember, now, that, to regulate the point steam rods. A change in the exhaust rods likewise affects the cushion and release. After the eccentric has once been properly set, it is not necessary to disturb it in ordinary cases. If the dashpot rod is too short,

FIG. 5.

of cut-off so that the same amount of steam is admitted at both ends, we adjust the lengths of the reach rods; to give more or less steam lap, we lengthen or shorten the the latch will not hook. Look out for this. It is an excellent plan to mark every position; you can then tell at a glance if it has been disturbed.

UNITED STATES WARS.

Wars.	Date of Commencement.	Duration.	Number of Men in Service.
War of the Revolution	1775	7 years	368,410
Indian Wars in the Northwest	Sept. 19, 1790	5 years	8,983
War with France	July 9, 1798	2 years	4,593
War with Tripoli	June 10, 1801	4 years	3,330
Creek Indian War	July 27, 1813	1 year	13,781
Great Britain, 1812	June 18, 1812	2 yr. 8 mos.	576,622
Seminole War	Nov. 20, 1817	1 year	7,911
Black Hawk	April 20, 1831	1 yr 6 mos.	6,465
Cherokee	1836	1 year	9,494
Creek Indian	May 5, 1836	1 yr 5 mos.	13,418
Florida Indian	Dec 23, 1835	6 years	41,122
Aroostook War	1838	1 year	1,500
Mexican War	April 14, 1846	2 yr 3 mos	101,282
Apache, Navajo, and Utah	1849	6 years	2,561
Seminole War	1856	2 years	2,687
Civil War*	April, 1861	4 years	2,772,408
War with Spain	April 21, 1898	113 days	274,717

* Confederate troops, 800,000 additional

NAVIGATION.

Ernest K. Roden.

HISTORICAL PROGRESS OF THE ART—DEAD RECKONING NOT TO BE RELIED UPON TO ANY GREAT EXTENT—NAUTICAL ASTRONOMY—INSTRUMENTS USED.

THE art of conducting a ship, with safety and despatch, from one place to another, across the trackless ocean, and, more particularly, the determination from time to time, and at any time, of the position of the ship, is called *navigation*. As a practical art, navigation is employed by many; but, even among those who make daily use of it, there are comparatively few who understand its fundamental principles; and this, in spite of the fact that its most conspicuous feature is simplicity itself.

History tells us that navigation was first practiced by the citizens of Tyre. These energetic people did much to cultivate foreign commerce, and made their city the great emporium for the trade of Europe and the East. As time went on, and the merchant fleets from Tyre spread through the Mediterranean, many colonies were founded, the most famous of which—Carthage—soon not only equalled, but surpassed, in importance, Tyre itself. From the sixth to the fifth century, B. C., the Greeks made considerable progress in the art of navigation, and during the Peloponnesian war the Athenians displayed remarkable skill in naval tactics. It would be difficult to enumerate the successive steps by which the art of navigation has been brought to its present high state of perfection; but as conspicuous points in its history, the following will perhaps suffice: the invention of Mercator's chart, 1569; the formation, by Wright, of tables of meridional parts, 1597; Davis's quadrant, about 1600; the application, by Gunter, of logarithms to nautical calculations, 1620; the introduction of middle-latitude sailing, 1623; the measure of a degree on the meridian, by Norwood, 1631. Hadley's quadrant, a century later, rendered observations easier and more accurate; while Harrison's chronometer, 1764, made the computation of longitude a matter of comparatively small difficulty.

Navigation is divided into two branches —*dead reckoning* and *nautical astronomy*. These two methods, while absolutely independent of each other, are in practice generally carried on together, one serving as a check upon the other.

When a vessel is about to leave one port for another, she is usually conducted out of the harbor by a pilot. This pilot lays his courses by the ranges with which long acquaintance has made him familiar. Arrived at the limit of his field of usefulness, that is, at a point where his local knowledge is of no further value, he leaves the vessel, and from there the navigating officer assumes all responsibility. While in sight of land, the navigator steers his ship by his charts and by the lead, assisted during the day by landmarks and buoys, and at night by lights. It is his duty, while off the coast, to keep the lead going quite frequently, no matter how fine and clear the weather may happen to be, or how confident he may feel as to the exact position of his vessel. When, finally, he is about to lose sight of land, a last position, called the *point of departure* is determined, which point then serves as a base for future operations. The problems involved in a long voyage are many and various, and often the commanding officer's skill and courage are taxed to the utmost. However, the ship's position is always ascertainable, either by dead reckoning or by observations of celestial bodies. Speed and direction are two very important factors to the navigator. The first is found by the *log*, and the second is indicated by the *compass*, from which is read the angle between the magnetic meridian and the ship's keel; this angle is generally known as the *course*. The log, the unit of which is the knot, predicates the number of nautical miles (6,082 feet) traversed per hour; but the log is not an accurate instrument, nor is it possible, in a sailing vessel, to take as many readings as the frequent changes in the speed of the vessel would call for. Again, the course of a vessel is not always the one read on the compass, because the action of the wind on the sails produces a certain side-push, forming an angle with the keel, and resulting in a falling off from the true course. This angle is known as *drift*, and the amount of it is usually ascertained

from the wake of the ship by a backsight of the compass, and combined with the magnetic variation, in order to obtain the true course. Allowance must also be made for the influence of local, tidal, or ocean currents, the strengths of which are either indicated on the charts or known by experience. Currents always seriously interfere with the calculations of a navigator, and too much attention can never be paid to them. The course and speed of a vessel are noted at the end of each hour on a tally, and at the close of each watch (every fourth hour) it is transferred to the log book. Every day at noon—or oftener, if deemed advisable—the reckoning is cast up, and the position of the vessel is marked on the chart, taking as a base the last ascertained position. All navigation by dead reckoning is checked at least once a day, and as often and in as many different ways as can be accomplished by observations of celestial bodies.

Dead reckoning is comparatively simple, is easy to practice, and may be relied upon for short distances; but there are several causes which render it untrustworthy during a voyage of any length. The various strengths of the different currents which the ship may happen to enter will materially upset the accuracy of it. For instance, a ship bound west from some English port, and steering a due westerly course, is caught by an unknown current, running north with a velocity of, say, five miles per hour. Should the navigator, under such circumstances, depend entirely upon dead reckoning, the probability is that he would be wrecked somewhere on the coast of Newfoundland, at a time when he thought himself several hundreds of miles away from the nearest shore, since there would be nothing whatever in the appearance of the sea to indicate the existence of any current. Again, a ship may run into a series of furious, changeable gales, that toss it about for days and leave the dead reckoning in a state of entire muddle and confusion. At such times the ship's safety depends solely upon that branch of navigation defined as nautical astronomy.

The first astronomical observation at sea is usually a meridian altitude of the sun, for the purpose of obtaining the *latitude*. In order that the reader may understand how the latitude is found, a brief description of this method will now be given. In Fig. 1 the line $P P'$ represents the axis of the earth produced to the celestial sphere, $E E'$ the earth's equatorial plane, similarly extended, and $H H'$ the horizon of the observer, stationed at m. Now, the latitude of a place on the earth's surface is defined as the angular distance north or south of the equator, measured on the meridian running through the place; and, since the meridians all intersect at the poles p and p', the latitude of the place m is the arc $m e$ on the meridian $p m e p'$. To obtain a value of this arc $m e$ (which is equivalent to the arc $Z E'$ on the celestial meridian), assume the sun to be situated at S. Then, $S Z$ is its zenith-distance, $S E'$ its declination, and $S H'$ its meridian altitude. Hence, the angle $Z o E'$ is equal to $Z S + S E'$, or, in other words, the latitude of m is equal to *zenith-distance* + *declination*. Zenith distance is the complement of the altitude, and is either north or south—north, when the sun is bearing south, and south when the sun is bearing north. The declination of the sun is found in the

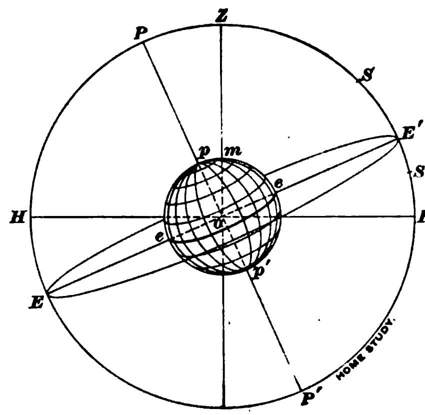


FIG. 1.

"Nautical Almanac" for every day of the year, and is either north or south, its maximum value being 23½°.

Again, should the sun be at S', and its declination $E' S'$ south, $Z S'$ being the zenith distance, the angle $Z o E'$ is equal to $Z S' - E' S'$, or the latitude in this case equal to *zenith distance* − *declination*. Hence, the latitude of any place is equal to the *sum* of zenith distance and declination, when both have the same name, and to the *difference* when they are of contrary names, the latitude then having the same name as the greater of the two. A meridian altitude of the sun is always taken at noon, or at the moment when the sun has reached its point of culmination; but to the *observed* altitude must always be applied certain corrections, such as "dip," "refraction," "semi-diameter,"

and "parallax," in order to obtain the *true* altitude. The description of the nature of these corrections does not, however, lie within the scope of this article.

Finding the latitude by a meridian altitude of a star differs from a similar operation for the sun only in so far as there is no semi-

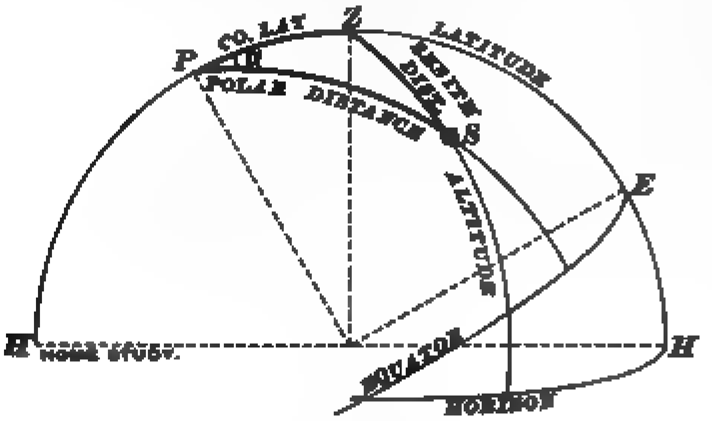


Fig. 2.

diameter or parallax to be applied. When, as often happens, the sun has been obscured for a day or two, star observations become of great value, for which reason a navigator should know all the principal stars, so as to recognize them during even a very partial clearness of the sky.

The *longitude* at sea is usually determined by computing the hour angle of a celestial body, the altitude of which has been measured by a sextant. From this hour angle is obtained the local time for comparison with the Greenwich time, as registered by the chronometer. The longitude of any place on the earth may be defined as the angle at the pole between the standard meridian and the meridian passing through the place, and this, of course, is equal to the arc of the equator, intercepted between the two meridians, and measured east or west 180°. Any meridian can be used as the standard, but almost every nation, except the French, use the one which passes through Greenwich. Since the circumference of the earth is 360°, the sun, in making its apparent daily circuit in 24 hours, moves through 360°; hence, in one hour it moves through $\frac{360}{24}$° or 15°. When the sun is on the meridian of any place, it is noon there, hence the time at any place 15° east of that meridian will be one hour *past* noon, and at any place 15° west of the meridian, one hour *before* noon; from this it is evident that if the navigator knows the difference between his local time and that of any standard meridian — Greenwich, for instance—he has a means of determining the longitude of his ship. The greater the difference of longitude, the greater the difference of time between any two places; from this it will be seen that the two questions of time and longitude are so intimately connected that they may almost be said to be identical.

Finding the hour angle is simply the solution of the spherical triangle PZS, Fig. 2. There the sun's position is indicated by S, the zenith distance by ZS, the polar distance by PS, and the arc PZ is the complement of the latitude ZE. Hence, the three sides of the triangle are known, from which the angle at P (the hour angle) can be computed.

Observation for the hour angle is generally made, *not* at, or near noon, but when the sun, or the observed body, is near east or west, which usually happens about

Fig. 3.

eight in the morning, and four in the afternoon. Where great accuracy is wanted, as is the case on shipboard, it is usual to work this question by means of the logarithmic sines, cosines, etc. The hour angle computed, the longitude follows at once, being simply the difference between the Greenwich time and the local time of the ship.

There are other methods by which the longitude can be determined: by lunar distances, Sumner's method, etc., but space does not allow any description of either here. Great accuracy is indispensable in any of these operations, because if one hour of time corresponds to 15 degrees of longitude, a mistake of one minute will make a difference of 15 miles in the position of the ship.

The difference between the observed position of the ship and the position indicated by dead reckoning is full of interest. It may be due to a current which has drifted the ship in one direction, or to the leeway made by the ship, and insufficiently allowed for in the log, or it may be the result of careless steering on the part of "the man at the wheel," or from inaccuracy of the officer whose duty it has been to record the course and speed. Whatever the cause, that of the current should be the last explanation to be accepted by the captain. However great the difference between the two results, the position derived from astronomical observations is always accepted as the true position of the ship.

The instruments used at sea for measuring angles and altitudes are the quadrant (*a*) and sextant (*b*), shown in Fig. 3. They are practically the same instrument; the first is the eighth part of a circle, and by reflection measures an angle of 90°; the second is the sixth part of a circle, and measures an angle of 120°. Both are fitted with verniers graduated in such a manner that the angle on the arc of the quadrant can be read to half a minute, and that on the sextant to ten or even six seconds.

The chronometer is merely a very accurate watch, which is carefully rated while the vessel is in port. It is set to Greenwich time, and by allowing for its gaining or losing, the navigator has the Greenwich time itself, with an accuracy which depends only on the uniformity with which the chronometer works; it makes no difference to what extent it either gains or loses time, provided its daily rate of motion is uniform.

To facilitate nautical calculations, there is annually published a book called the Nautical Almanac, prepared at the Royal Observatory at Greenwich, in which all the movements of the sun, moon, planets, and principal stars are tabulated.

In this article, the writer's sole purpose has been to give the reader an approximate insight into the manner in which a ship is conducted from one port to another, and to show that the determination of a ship's position at sea is a problem to which astronomy mainly owes its economic importance.

It is indeed to the heavenly bodies alone that the mariner can look for his guidance; those brilliant, silent stars speak to him in a language that the landsman knows not, and their appearance amidst ragged skies, during the darkness of a stormy night, brings to him a feeling of boundless confidence and security.

RUBBER STAMPS FOR BLUEPRINTING.

WE HAVE received the following letter and contribution from Mr. C. Francis Jenkins, of Washington, D. C.:

"Enclosed find little squib for HOME STUDY MAGAZINE. I believe it is new, and will be useful to many of your readers. As I have been a reader of your splendid paper for but a short time, allow me to extend my congratulations, although tardy, on the excellent character of the matter presented.

"Almost every engineer or architect has a business card on a rubber stamp, but has found that the impression made by it on the tracing is useless for purposes of reproduction on a blueprint. Here is the method I have been using for some years to overcome this defect: The impression of the stamp is made upon the tracing linen, and, while the ink is still moist, it is dusted over with lampblack, soot, or the like, with a tuft of cotton. The ink takes up the pigment, which is actinically impenetrable, and the impression washes out splendidly on the blueprint. All draftsmen will appreciate the saving of time this little wrinkle permits."

THE PREPARATION AND USE OF GLUE.

George F. Lord.

MATERIALS FROM WHICH GLUE IS MADE—PROCESS OF MANUFACTURE—PREPARATION FOR USE. A HOME MADE GLUE POT—HOW TO JUDGE THE QUALITY.

IT IS surprising how little is known about glue, even among artisans who are constantly using it in their work, especially when we consider that the strength and durability of glued work, and, ultimately, the reputation of the artisan, depend largely upon the quality and proper use of it.

It is an indisputable fact that poor glue, or the improper use of good glue, has caused the wreck of many an otherwise good piece of work.

In order to select or handle glue intelligently, it is necessary to understand something about its manufacture. Glue is an impure gelatine, and is made from the refuse of tanneries, such as parings and waste pieces of the hides, ears, and tails of cattle. Some light-colored glues of poor quality are made from sheep skins, pig skins, and bones. Bone glue is prepared by boiling bones, to remove the fatty matter they contain, and then treating them with hydrochloric acid. This renders them soft and translucent. They are then washed in an alkaline bath, to neutralize the acid. The subsequent treatment is much the same as that followed in the other process. Glue made from bones has a milky hue, owing to the presence of phosphate of lime.

A very strong, though offensive smelling, glue is made from fish bones, but the most reliable and economical glue for the woodworker is made from sinews and pure hide stock. In preparing this glue, the clippings are first soaked in quicklime and water for two or three weeks. This removes the hair and acts as an antiseptic. They are then washed and given another lime bath; then washed again and partially dried, or drained, in the open air. When well drained, the "glue pieces," as they are now called, are placed in large, flat-bottomed boilers of copper. These boilers are provided with false bottoms, to prevent the material from burning. The pieces are partly covered with soft water, and gently heated until all the gelatinous part has been dissolved out and the remaining glue has attained the proper consistency; it is then drawn off into "congealing boxes" of wood. As it cools, it becomes stiff and jelly-like, when it is turned out and cut with wires and wet knives. The pieces are then removed to drying racks, where they are supported on nets and dried in the open air. This operation of drying is often a cause of much anxiety to the manufacturer, the reason being that decided variations in temperature have disastrous effects on the product. When dry, the dull appearance of the pieces is not very pleasing, and to give them a bright gloss they are wetted and subjected to artificial heat.

A knowledge of the processes followed in the manufacture of glue enables the consumer to readily judge the merits of any sample offered. The color is a matter of great importance. Good hide-stock glue is clear, light brown, free from streaks or specks. As already mentioned, very light colored glues are usually inferior. A very dark color indicates that poor material was used or that the glue was obtained from a second boiling of the glue pieces. Muddy glues are sometimes bleached by the addition of zinc or whiting; the result is, of course, a very poor quality; but some furniture manufacturers use such glue, as an excess of it on the work is not readily seen, and the expense of cleaning it off is saved.

Another test for glue is to break a piece of it. Good glue, if bent quickly, will snap into pieces with a glassy fracture; but, when bent slowly, it will bend nearly double, turning white at the bend, before breaking.

Some kinds of glue that are made by the acid process, have an acid taste. This indicates that the acid was not properly neutralized, and this has a detrimental effect.

A very important test of glue is that which determines its "water-taking" properties. In this test, the dry glue is placed in the glue-pot, and cold water poured upon it. Good glue will not *dissolve* in cold water, but will *absorb* the water. Poor glue will absorb very little water, while a first-class quality will absorb an astonishing amount, swelling up until it stands above the top of the glue-pot. This alone should prevent any

one from buying cheap glue, under the impression that it is economical. Water is cheaper than glue, and a pound of good glue will make two or three times the amount of prepared glue that a pound of poor glue will make.

When preparing glue for use, no more should be dissolved than is needed for immediate application; glue is animal matter and, like ham or beef, will go bad if exposed. The pieces should be soaked for about 24 hours, or at least overnight, in as much water as they will absorb. Then, with the addition of a little more water, they should be boiled in a glue-pot or double cooker. The pot containing the glue should be surrounded by water and steam, and should never come in direct contact with any heating flame, as a temperature higher than that of boiling water is detrimental. The glue should be boiled until all the lumps are dissolved and the liquid has the consistency of heavy oil. Some classes of work require thick glue, and others thin glue. If the glue is too thick, it may be thinned by stirring in some hot water. A very convenient glue-pot, made of simple materials, is shown in the accompanying figure. The outside can is such a one as contains a pound of infant's food. A hole may be cut in the cover just large enough to admit the body of a small baking-powder can. This answers very well for home use.

In making a glue joint, it is necessary that the pieces fit together exactly, and are perfectly dry. It is also a good plan to warm the surfaces to be glued. The strongest joints can be made when the grain of the wood lies in the direction of the joint. End wood joints are very difficult to make secure, and require thick glue.

Among amateurs there is a common misconception that the more glue used, the stronger the joint. This is a great mistake, for while it is necessary that all parts of the joint shall receive a *coating* of glue, the effort should be to immediately squeeze out as much of it as possible. A perfect joint should be discernible only by the difference in direction of the grain of the wood, and not by a black streak. The strength of a properly glued joint is very great; in fact, when tearing apart glued articles—furniture, for instance—the wood itself often separates before the joints will yield.

In some shops, it is the custom to make up a quantity of glue sufficient for several days' work, and allow the men to replenish their supply from this "stock solution." This is a bad practice, as glue which is allowed to stand in moisture rapidly ferments and loses its strength.

If, after a glued joint has stood for three or four hours, the glue sticks to the chisel when an attempt is made to clean off the surplus, it indicates that the glue was not cooked enough.

In drying, glue should return to nearly the same condition as before cooking, although in warm or damp weather it will not dry as fast as in cold, dry weather.

In wood-working establishments glue is useful in a way which many people know nothing of, namely, as a healing agent. This is particularly fortunate, for at the cabinet-maker's and in the pattern shop, etc., where glue is always at hand, finger cuts are frequent and need prompt treatment. If the injured part is wrapped with a piece of paper that has previously been covered with hot glue, the cut will stop bleeding instantly. The cut should be drawn together well while applying the glue-covered paper. In cooling, the glue contracts and tends to still further close the wound, in much the same manner as the collodion used by the surgeon. When the finger has healed, the paper can be readily washed off in warm water.

For some classes of work, ready-made liquid glues are very convenient; but they will not answer for large joints, as they dry

very slowly. For small work, however, and for mending crockery and glass, they answer very well. Common glue should never be placed in contact with glass, as it contracts so rapidly that the glass is certain to break.

Liquid glue may be made by dissolving 1 part of isinglass in 3 parts of No. 8 acetic acid. Another recipe is to slowly add nitric acid to the ordinary preparation of glue, in the proportion of 10 ounces of the acid to 2 pounds of ordinarily prepared glue. A damp-proof glue can be made by using skim milk instead of water, and preparing in the usual manner.

In making a joint with any kind of glue, the surfaces to be joined must *fit* each other, and as much of the glue as possible squeezed out, either by rubbing the pieces back and forth, over one another, or by squeezing them together between the hands.

Where the joints or the pieces are large, clamps or presses may be used with advantage for squeezing the glue out. The clamps should remain on the work until the glue has set; this takes from half an hour to several hours, according to the temperature and humidity of the air. Cabinetmakers usually screw their clamps up very tight, and immediately afterwards release them slightly, to take the strain off the screws. If this is not done, the clamps are very apt to give way in a short time.

In working with hot glue, everything should be ready before the glue is applied, as it begins to chill immediately, and if exposed to the air too long, a poor joint is the result. The stock of glue should never be kept in a damp place, or the glue will mold and spoil.

INSECTS ON THE DISSECTING TABLE.

Adam Kaufman.

THE BIOLOGY, PHYSIOLOGY AND ANATOMY OF A CARABID OR GROUND BEETLE—NAMES OF APPENDAGES—DISSECTION OF INTERNAL ORGANS—THE ALIMENTARY CANAL.

AMONG those who take a genuine interest in the study of insect life, there are comparatively few who do more than simply collect and mount specimens. There are some, however, to whom the study of economic and systematic entomology becomes so fascinating as to induce a desire to know something of the structure, and mode of growth of an insect. To these, a few hints on how to carry on a study of this kind, and a description of what the dissecting table reveals, will perhaps be interesting.

Of the known varieties of life in the animal kingdom, about four-fifths are insects. In point of numbers, then, they far exceed any other family. This the reader will, perhaps, be quite ready to believe; but he will probably be surprised to learn that in their structure, insects are the most complicated of all living creatures. This is partly due to the serial arrangement of their segments, with the consequent repetition of organs, and especially of appendages, muscles, tracheæ, and nerves.

There are three closely allied sciences which bear upon the study of insect life, namely, biology, physiology, and anatomy. Biology is the science of life or living organisms. Physiology is really a branch of biology, but treats especially of the vital phenomena manifested by animals and plants, and of the functions of every organ or part of a living organism. Anatomy treats of the structure of organisms, whether visible to the naked eye or only with the aid of the microscope.

The accompanying figure shows the external and internal anatomy of a *carabid*, or ordinary ground beetle; for its dissection and study, a specimen preserved in alcohol is necessary. Take a beetle which has been killed in a cyanide-of-potassium bottle and placed in alcohol for a short time, and with a pair of fine forceps and a needle mounted in a handle, remove the appendages of the mouth, the antennæ, and legs, and cut off the wings with a pair of scissors. These may be microscopically examined with a lens mounted in a holder, so that both hands can be used in dissecting. The appendages may be gummed to a card.

The body of an insect consists of not more than twenty-one segments, which are usually of unequal size and shape, and are divided into three well defined parts: the head, thorax, and hind body, or abdomen. The

thorax is usually somewhat larger than the head, while the abdomen is the largest part, and consists of from ten to eleven segments.

In general it may be said that the head contains the organs of sense, of prehension, and mastication of food; the thorax contains the organs of locomotion; and the abdomen, those of reproduction.

The external parts of the body of a carabid beetle as seen from the under side are as follows: The mandibles *A* are the jaws, adapted for cutting, tearing, or crushing the food, or for defense; bees use them as tools for modeling wax; other insects use them as brushes for collecting pollen. The antennæ *B* are many-jointed appendages, and are generally inserted between or in front of the eyes, and are moved by very small muscles at the base, within the head; they are the organs of tactile and olfactory sense, and are used for feeling and smelling. The labrum *C*, or "upper lip," is moved up and down when the insect moves its mandibles. Under the labrum are the paraglossæ *D*, and the ligula *E*, *F* is the labial palpus, *G* the maxilla inner lobe, and *H* the outer lobe; *I* the mentum, *J* the gula, *K* the buccal fissure, *L* the prosternum, *M* the prosternal episternum, *N* the prosternal epimerum, *O* the coxal cavity, *P* is the inflexed side of the pronotum, *Q* the mesosternum, *R* the mesosternal episternum, *S* the mesosternal epimerum, *T* the metasternum, *U* the ante-coxal piece, *V* the metasternal episternum, *W* the metasternal epimerum; *X* is the inflexed side of the elytrum, *Y* the ventral segments, *1* the posterior coxæ, *2* the trochanters, *3* the femora, *4* the tibiæ, and *5* the tarsi.

The dissection of the internal organs of insects requires delicacy of manipulation and untiring patience. The internal anatomy may be studied by removing the dorsal wall of the body, after hardening the insect for several days in alcohol, and cutting it in two, longitudinally, with a sharp scalpel. The insect may be pinned to a thin piece of sheet cork, placed in a tin or porcelain dish, or it may be partially imbedded in melted beeswax or paraffin

By carefully cutting along each side of the back with a pair of fine scissors, and removing the dorsal portion of the integument, the alimentary canal, which passes through the middle of the body, will be disclosed.

The food after being cut by the jaws passes through the esophagus *a*, which is short and curved, into the crop *b*, where it is acted upon by an alkaline salivary fluid which possesses the property, as in vertebrates, of rapidly transforming the starchy elements of the food into soluble and assimilable glucose, or sugar; it is then gradually filtered through the short, small proventriculus *c* into the chyle-stomach, or ventriculus *d*.

In the stomach the portion of the food which has resisted the action of the crop is submitted to the action of a neutral or alkaline liquid, secreted by special or local glands, and then passes through the pyloric orifice into the intestine ileum *e* and colon *f*, where the active absorption of the liquid portion of the food takes place; the rectum *h* is the stercoral reservoir. The two urinary tubes *g* pass their secretions, such as the calculi or crystals of oxalic, uric, or phosphatic acid, into the intestines; *i* are the anal glands.

There are no special vessels in an insect to carry off the chyle, such as the lacteals or lympathics of vertebrates; but it passes through the fine coatings of the digestive canal and mingles outside of this canal with the currents of blood which pass along the ventral and lateral parts of the body.

The nervous system of an insect consists of series of nerve-centers or ganglions which connect with the head, thorax, abdomen, and other parts of the body.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

Great Britain and Egypt.

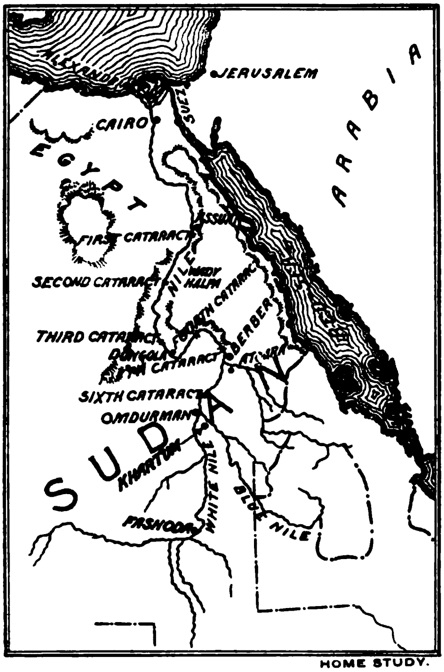
THE recent war between the United States and Spain has naturally been of such preeminent importance to Americans, that they have had little attention to spare for a conflict which was in progress at the same time on another continent—the reconquest by Egypt, under the leadership of British officers, and with the assistance of British troops, of her revolted province, the Sudan. The conditions under which these two wars have been carried on were dissimilar; but, whatever may have been the secondary motive involved in either case, the ultimate object of each was the same, namely, the deliverance of an oppressed people from a cruel and tyrannical despotism. The year 1898 will be distinguished in history as one in which each of the two great branches of the Anglo-Saxon race engaged in war for the sake of humanity. But the war in the Sudan had for its object the rescue of a country and a population far larger than Cuba and the Cubans, from cruelties beside which the tyranny of the unenlightened government of the Spaniards sinks into insignificance.

The Eastern Sudan, which became a province of Egypt under Mohammed Ali, sixty or seventy years ago, is a vast region to the south of Egypt, with ill defined southern boundaries. It extends for more than a thousand miles along the valley of the Nile, and includes much fertile land. Egypt found that she had not strength to hold this province, and it was abandoned in 1885, after vain attempts to put down a revolt against the authority of the Khedive. Like most other Mohammedan rebellions, this was nominally a war of religion. A prophet, known as the Mahdi, arose in the Sudan, and drew to his standard fanatical warriors belonging in part to the Mohammedan religious orders, and described under the general name of *Dervishes*. They found many adherents amongst the barbarous and warlike tribes of the region, and the movement assumed such proportions that the Egyptian government, which then had only a very inferior army, could not cope with it. For thirteen years the Sudan has been the scene of cruelty and barbarism of the worst kind; the country has been ravaged, and more than half the population has been exterminated. The southern boundary of Egypt proper, which crossed the Nile at Wady Halfa, was never safe from incursion and attack on the part of the Dervish army. The commerce, which had been of much value, and might have grown into a great source of revenue for Egypt, was destroyed.

If the revolted province had been under a just and stable government, Egypt would probably have resigned herself to her loss, and devoted herself to the development of her diminished area. For years she had been struggling under a load of debt, and she was threatened with the destruction of her national existence. But such an enemy to order and good government could not be tolerated on her frontier. Circumstances which will hereafter be indicated had caused Great Britain to assume the position of predominant power in Egypt, and it became her interest and her duty to promote civilization in the region which was under her influence. Under the leadership of British officers an Egyptian army was organized and trained; the peasants—or *fellaheen*—once despised as weak and cowardly, developed into steady and reliable soldiers; the black tribes of the Sudan, who had tasted the cruelties of Dervish rule, proved to be born fighters, and supplied valuable recruits. A contingent of British troops, in number about one-third of the whole Egyptian force, served at once as nucleus and support for the new native army. In 1896, after spending ten years in careful training, General Sir Herbert Kitchener, a British officer who filled the position of sirdar, or commander-in-chief, under the Egyptian government, began the campaign, which has now had a brilliant and successful termination.

For two years and a half the advance towards Omdurman and Khartum, the stronghold of Dervish power, has been steady and irresistible. There has been no haste. With foresight, discipline, and scientific deliberation, the fortified posts have been pushed forward; and the Egyptian

troops, with their many clever and capable native officers, who lacked only the encouragement of the glorious traditions belonging to older armies, gained courage and stability with each new success. The first summer's work resulted in the capture of Dongola, in September, 1896. A railroad was constructed, in part parallel with the Nile; in part crossing a desert space which lies infolded by a great bend in the course of the river. Points were thus brought near together which were separated by journeys of many hundred miles for those who traveled by water. Between Assuan in Egypt, and Omdurman, the objective point of the army, six cataracts



HOME STUDY.

interfere with the navigation of the Nile, which can be traversed only when the rive is in flood, during the summer months. The railroad, as far as it extends, was used for the transportation of most of the troops, and for the lighter traffic; but the river as a highway was essential during a part of the campaign, so the final advance had to be made under the blazing summer sun of this tropical region.

The battle of Atbara, fought last April near the junction of the Atbara River with the Nile, although an important action, was recognized as preliminary to the great struggle. All natural obstacles to the progress of the forces were quietly and steadily overcome; gunboats accompanied them up the river at the season most favorable to navigation; and last September an army of 24,000 men, with a sick-list averaging less than two per cent., was concentrated 1,200 miles from its base of supplies at Cairo, and within striking distance of the Dervishes, who were fully prepared for conflict. In the battle of Omdurman, on September 2, the destruction of the Mahdist power was accomplished, to use the words of the Paris "Temps," of September 4, 1898, "according to a general plan so scientific that the march may be likened to the solution of a mathematical equation." It will long be remembered for the military strategy and courage which were displayed, but especially for the brilliant charge of a body of British cavalry, 350 strong, who broke up a flank attack skilfully planned by the Dervishes. The Khalifa, who in 1885 succeeded to the power of the original Mahdi, or prophet, was not captured, but his forces were completely dispersed, and the local tribesmen combined in pursuit of him. Before the end of the year he will probably have been taken. It is worth noting that the expense of this campaign, lasting two years and a half, was only $13,000,000; and two-fifths of this sum were spent in the construction of five hundred miles of permanent railway.

Such is the conflict in which our kindred beyond the sea have been engaged, while we have been fighting for freedom in Cuba. Americans and Cubans—British and Egyptians—stood side by side, the strong striking a blow for the weak—training, encouraging, aiding, supporting. The selfish motives which actuate every nation in war are in both these cases distinctly secondary. The United States may be the better for the pacification of Cuba, whether the island becomes a small, independent republic, or eventually a part of the greater one. Great Britain may be the better for the advance in civilization and the increase in prosperity of the country whose cause she has espoused, and in which she has undertaken to restore order. It is altogether unlikely that in either case every person concerned has been actuated by motives of pure philanthropy. But, none the less, each war has been waged for humanity, for freedom, for mercy, and for justice. In each the hand of the good Samaritan has been stretched out to help him who fell among thieves. The American became the "neighbor" of the Cuban by force of natural proximity. The circumstances which have brought Great Britain

into the position of "neighbor" to Egypt in this struggle are more complicated, and may be briefly described.

Egypt is a province of the Ottoman Empire, and is governed by a khedive, or viceroy, whose office is hereditary, and who possesses powers which are almost as great as those of an independent sovereign. Ismail, who became Khedive in 1863, had received the greater part of his education in France, and recognized the importance of Western civilization. Possessed of energy and ability, he yet was a spendthrift, loving show and luxury, and lacking in judgment and in the common prudence with which a private individual—and much more the almost irresponsible ruler of a nation—should govern his affairs. He had great schemes for the development of his country's resources, for agriculture, irrigation, public buildings, and the construction of the Suez Canal; he forestalled and spent all available revenue, and borrowed recklessly from all the countries of Europe with which he could negotiate loans. In thirteen years the debt of Egypt grew from $15,000,000 to nearly $450,000,000, and the taxation on the land was increased fifty per cent.; yet the entire national revenue amounted to not more than $45,000,000 per annum.

The Great Powers of Europe stepped in at this juncture for the protection of their respective countries, to which Egypt was indebted. They insisted on the appointment of a commission, in which the Powers should be represented, whose duty should be to put the exchequer of Egypt on a sound footing, and secure the payment of interest, and the gradual liquidation of the debt. This resulted in the formation, under a new khedive, of a ministry, or cabinet, in which important posts were held by British and French officials. Egypt's financial affairs were regulated, and the worst appeared to be over.

But a section of the people, including many soldiers, rebelled against the preponderance of foreign influence in their government, and headed by Arabi Pasha, the Secretary of War, they revolted against the Khedive in 1882, attacked Alexandria, and drove out the hated Europeans, killing many of them and injuring their property. Great Britain and France were expected to unite in suppressing this rebellion, which endangered the newly established schemes for financial reform. France, whose skill and influence had been of great use to Egypt in the past, declined to render assistance, leaving Great Britain to act alone in upholding the authority of the Khedive. She accomplished her task, and has since been the predominant power in Egypt. The duties incidental to this position were unwillingly assumed, in the face of much opposition from the British parliament and nation; but the so called "Occupation" once begun will probably be maintained until the Egyptians have learned the art of governing their country according to modern methods, which they are slowly acquiring. Meanwhile, the financial obligations of the country are met, and the balance of revenue which is available, after annual charges for interest and for the expenses of the government have been paid, is devoted to the improvement of the country, and has already borne fruit in the increase of productive power, and, consequently, of national wealth.

The condition of the population has been changed for the better in innumerable ways, yet the Occupation is not acceptable to a large number of the people. The British officials who are in power endeavor to exercise the simplest ideas of honesty, humanity, and justice. But the Oriental habit of mind does not easily assimilate the systematic, orderly methods of the British administration. The Egyptians appreciate the fairness and equality with which justice is dealt out between man and man—except when a would-be oppressor himself feels the restraining hand of the law. They rejoice in the lightened taxation, collected lawfully and fairly, and no longer farmed out to middlemen. They are thankful for the abolition of the *corvée*, or system of forced labor, which has been in practice since the days of the pyramid builders, permitting the government to call on the *fellaheen* at any time to toil on public works without payment. They are now liable to be summoned only in emergencies, such as the locust plague of 1891, or for the repair of occasional sudden breaches in the embankments of the Nile. The carefully husbanded resources of the country are spent on schools, railroads, the post office, and the administration of justice; on irrigation, on sanitary improvements, on an efficient police, and a small but well trained army. The people generally would suffer if left now to the native administrators, who, released from the master's eye and the master's example, might be expected soon to sink back into the weakness and corruption of the ordinary Oriental government. But the rule is that of the foreigner and of the Christian, and it is unwelcome. The

individual Briton and the individual Egyptian may be excellent friends, but a new generation must arise before the whole country can heartily indorse modern methods. Nevertheless, in the interest of the European creditors, the receivers must for the present retain control of the effects of the bankrupt nation, and their authority, under the Khedive, is supported by a garrison of from three to five thousand men.

It is certain that the British government and the British people do not contemplate the annexation of Egypt, in the ordinary sense of the word. They do not mean nor wish to make it part of the British empire. But, in view of the expenditure of British blood and treasure, and of the connection of Egypt with the Suez Canal and the Red Sea—the highway to India and the East—Great Britain does not intend to permit any other European Power to predominate over her own in Egypt. The value of the reforming hand is recognized by every country whose interests are involved, except perhaps by France, who feels that her ministers lost a great opportunity when they relinquished their share of authority in Egypt in 1882. Her "point of view" of Egyptian affairs is naturally different from that of her rival. She still holds certain powers there in common with other European nations, and the manner in which they are exercised often hampers the action of the British officials.

The position of Great Britain in Egypt is the subject of attack and of unfavorable criticism whenever international complications arise with her neighbors. With a curious (and some say a culpable) want of prudence and foresight, Mr. Gladstone, as Prime Minister, in 1883, undertook to withdraw the British troops from Egypt at an early day. No date was named, but a short interval, perhaps a year or two, was implied, and was probably meant by him at the time. It was certainly so understood by the other Powers. The withdrawal was to take place "as soon as the organization of proper means for the maintenance of the Khedive's power would admit of it." The opinion is now widely held that the promise—if it were a promise—would be broken in the spirit if it were kept strictly in the letter. To leave Egypt now to her own resources would be to invite anarchy. The authority which is exercised is for the welfare of the Egyptian people and for the progress of civilization, as well as for the interest of the bondholders, for whose security the government has made itself responsible. The wisdom of the course adopted is frequently questioned, but the belief is becoming general among careful observers that the time has not yet come for the withdrawal of the small body of troops which support British authority in the land of the Khedive, or of the officials by whom his government is largely controlled. If nations may be judged by rules similar to those which apply to individuals, Great Britain is likely to be stimulated by general criticism in her efforts to accomplish, to the best of her power, the task which circumstances have assigned to her in Egypt.

ADVICE TO INVENTORS.

G. Herbert Follows.

SOME years ago, when the London dailies were amusing their readers during the dull season with "Advice to those who are about to marry," Punch carried off the palm with the short but exceedingly pithy contribution, "DON'T!" Of course, Punch was joking; at any rate, that is evidently what people thought, for they only laughed, and went on getting married.

So it would be if the same advice were given to those "who are about to invent." In such cases, it is no use saying "don't," because people "will," you know. To those who are matrimonially inclined it is best to say absolutely nothing, because they *don't want* your advice—they have made up their minds. There are some inventors, however —unfortunately, very few—who *will* listen to reason. To them we would like to give a little advice. First, go slow, and give the thing a bona-fide trial. If it doesn't work as you expected it to, make such alterations as you believe will *make* it work, and try it again. If it still fails, try hard to be "common sensey," and drop it. But if it works all right, if it fulfils your wildest hopes, or "surpasses your most sanguine expectations," then call in a trusty, cool-headed

friend, and ask him to criticize it. Don't get mad because he asks questions about it, or doesn't see what use it is, or makes what seem to you idiotic suggestions, with the idea of improving it. Keep cool. Tell him—and be careful to modulate your voice as though you really mean it—that you have made up your mind you are not going to make a cent out of it, but that, of course, anything you *do* make will be very acceptable, though in the nature of a surprise. This is a very good thing to say. It may possibly induce your cool-headed friend to be honest and to tell you point blank that he doesn't think you ever *will* make anything out of it—but you must run that risk. Don't neglect your business on the strength of the fortune you are going to make—don't even rush into temporary extravagance; and, whatever else you do, *don't* throw up your situation.

If, as is generally the case, the invention concerns a class of article about which you know absolutely nothing, call in, next, an experienced man—preferably a middle-aged, well-to-do-man (and if he is gray-headed and wears a square-cut beard and has a good, deep voice, so much the better), and get *him* to criticize.

Of course, while he is present you won't think of telling him that he doesn't know anything about it; but when he has gone you may possibly feel inclined to say something of the kind. Well, don't do it. He knows, all right enough, and if he has told you that the scheme, though ingenious (he will probably say it is ingenious) is of no commercial value, drop it like a hot potato, and, as Sam Weller, Sr., said to his son, "you'll be glad on it arterwards." If, however, he advises you to patent it, go to a first-class patent attorney, and get him to make a thorough search to discover if your invention has already been patented. This will save you the possible mortification of finding out, after you have spent $75 or so on the patent, that the idea is a trifle older than your grandfather. If your attorney reports that something very similar to your invention was patented by a certain Obadiah Winterbottom, September 15th, 1893, of course you know what to do—"drop it." If the idea proves to be new and your friends (we purposely leave you out here, because, for the time being, your mind is supposed to be somewhat unhinged)—if, we say, your friends are of the opinion that, when your invention is put on the market, people will want it and be willing to pay for it, give your attorney instructions to go ahead and patent it. But don't, even now, throw up your situation, or position, or whatever you prefer to call it; go right on earning all the money you can, and, if possible, indulge in the customary 8 hours sleep; the chances are still 10 to 1 that you won't make anything out of your invention. When you possess the patent, go to the best firm you know of who would be likely to take up the manufacture and sale of the article, and show it to them. Oh yes! you may trust them; manufacturing concerns are not in business for the special purpose of swindling you out of a fortune; they don't care anything about you, so you needn't worry.

And now, when you are explaining your invention, try to behave like an ordinary individual. Don't quiver with excitement, or get red in the face, or parched at the throat, or anything of that kind. If the thing has merit, the less you say about it the better; after once being explained it will talk for itself. If the gentlemen you are showing it to, see money in it for themselves (yes, for *themselves!*), they may possibly take it up; but, if they *don't* see any money in it for themselves, they won't, if they are wise, have anything to do with it. It's as well to bear this in mind; otherwise, you may be led to imagine that their chief aim and object in life is to make money for *you*.

And now, assuming that they look favorably upon it and express a desire to come to terms, don't lose your head and talk about $10,000 being the lowest sum you will accept; because if you do they will know at once that this is your first offence as an inventor, and that you are foolish. Be reasonable. In all probability they won't give you cash for it at all, but will offer to manufacture, advertise, and sell the article on the basis of a royalty to you of from 10 to 20 per cent. on the retail price. If, however, they *do* offer you a lump sum, you can please yourself about accepting it.

But the chances are that the first people you show it to will decline to take it up on *any* terms. Here is a chance for you to show what kind of stuff you are made of. The $100 you have so far spent is money out of pocket that you must get back somehow or other, so you will try another firm, and if necessary another and another. Many a good thing has gone a begging before today. Of this you may be sure: by the time you have either succeeded or failed with your "first offence" you will be a wiser man in many ways.

THE COOKING OF WHOLESOME MEALS.

Mrs. Henry Esmond.

AN INEXPENSIVE BUT SATISFACTORY DINNER FOR THANKSGIVING OR CHRISTMAS DAY.

BILL OF FARE FOR DINNER.

Pea Soup. Croutons.
Roast Turkey and Giblet Gravy.
Cranberry Sauce. Celery.
Mashed Potatoes. Baked Sweet Potatoes.
Cauliflower.
Tomato and Celery Salad.
Coffee.
Mince and Pumpkin Pies.

Pea Soup.—Drain the liquor from 1 can of marrowfat peas; pour the peas into a saucepan and add 1 pint of water. Put on the fire and allow to cook until they break to pieces. Remove from the fire and rub through a sieve. Melt 1 tablespoonful of butter in a small saucepan, add 1 tablespoonful of flour, and mix well. To this add 1 pint of milk, a little at a time, beating vigorously all the time, to keep it smooth. When all the milk is added, pour it into a double boiler, add ½ teaspoonful of salt, a dash of white pepper, and the strained peas. Let this cook for 10 minutes, and strain. Serve immediately, with croutons.

Croutons.—Cut three slices of bread, ½ inch thick. Butter them and cut into pieces ½ inch square. Put in a pie pan and stand in a hot oven to brown.

Roast Turkey.—For a family of 6 or 8, about a 6-pound turkey is required. When buying a turkey, select one with smooth, black legs, and plump, white breast. Remove the head, then the legs to the first joint, and with a lighted paper singe off the hairs. Cut a slit *crosswise*, about 3 inches long, below the breast bone (it is better to cut this slit *crosswise* than *with* the breast bone, because, in the latter case, the skin is apt to split), and with the fingers remove the entrails, heart, lungs, and liver, being careful not to break the gall bag, which lies near the liver. Remove the membrane from the heart and liver, and the inside from the gizzard. Wash thoroughly and put them on to cook, in cold water. Cook until tender; these are to be used for the gravy. Pull down the loose skin of the neck; remove the pipes and the crop; then cut off the neck close to the body, leaving the skin so that it can be tied back after stuffing. When everything is out of the inside, hold the fowl under the cold-water faucet, and wash thoroughly; wipe *dry*, and it is ready to stuff.

Stuffing.—Soak in cold water 1 large loaf of stale bread, broken in pieces; squeeze out the water and add 1 tablespoonful of sage, 1 teaspoonful of salt, and ¼ teaspoonful of pepper. Cut 1 slice of fat, salt pork into small cubes, and fry out in a frying pan. Add to this 1 onion, cut in small pieces. Watch it carefully, to keep the pork fat from burning. When the onion is a light brown, remove from the fire and mix with the bread. If you do not like the pork scraps, remove them, but they give a nice flavor to the turkey. Put stuffing in at the neck—enough to make the breast plump. Put the remainder in the body, and sew up the slit with a coarse thread. Tie a string tightly around the skin of the neck; bring it down over the back, and tie the wings down close to the sides; fasten the legs down to the tail, and the turkey is ready for the pan. Spread the skin with butter, or bacon fat, and sprinkle with salt, pepper, and flour. Put 1 pound of link sausages in the pan, around the turkey, and pour about 1 pint of boiling water over all. Put into a moderately hot oven, and baste often. Allow 2½ hours for a 6-pound turkey, or 25 minutes to the pound. The skin, when the turkey is done, should be a golden brown all over. When ready, remove from the pan to a hot platter; cut and take off the strings, and garnish the dish with celery leaves, put the sausages around the turkey, and it is ready to serve.

Gravy.—When the giblets (the heart, liver, and gizzard) have become tender, pour off the water and chop them fine; put them in the pan in which the turkey has been roasted, and add 1 cup of hot water. Thicken with one tablespoonful of flour, moistened with a little cold water. Mix well, and cook for 5 minutes, being careful not to let it burn.

Cranberry Sauce.—Pick over and wash 1 quart of cranberries; put them on the stove to stew, with 1 pint of water, and let them cook slowly for 15 or 20 minutes. When they are broken, remove from the fire

and add 2 cupfuls of granulated sugar. Pour into a porcelain dish and let them cool. If you prefer a smooth jelly, strain the cranberries, after they are stewed, through a fine sieve; return to the fire, add the sugar and let it boil up once, but do not stir it. Remove, and pour into a bowl to cool. In either case, do not put the sugar with the cranberries *before* cooking, as it turns them a purplish red.

Mashed Potatoes.—Wash and pare 6 or 8 good sized potatoes. Let them lie in cold water for from 1 to 2 hours. If they are very old, let them lie two or three hours. Pour off the cold water and cover them with boiling water. Boil for 20 minutes, or until the potatoes are soft, but not broken. Drain off the water thoroughly and mash well; then add 1 teaspoonful of salt, 1 tablespoonful of butter, and ½ cup of cream or milk; beat hard with a spoon, until they are light and creamy. Pile lightly in a hot dish.

Cauliflower.—Select a firm, white head of cauliflower. Examine it carefully, to see that there are no worms in it. Remove just the outer green leaves, and put it in a pan of cold water, flower part down. If there are any worms or bugs in it they will then come out. Let it lie in this water for 1 hour. Tie it up in a piece of cheesecloth or white mosquito netting, and plunge into boiling water, and boil for from 30 to 40 minutes, or until tender. The reason for tying it up in the cloth is to prevent its breaking apart. When done, remove the cloth and put it, blossom up, in a deep dish, and pour a cream sauce over it.

Cream Sauce.—Melt 1 tablespoonful of butter in a small saucepan; add 2 tablespoonfuls of flour, and when well mixed, add 1 pint of milk, a little at a time, beating vigorously to keep it smooth. When all the milk is in, add ½ teaspoonful of salt; strain over the cauliflower through a fine sieve.

Sweet Potatoes.—Select potatoes as near one size as possible; scrub clean, cut off all the fine roots, and about ½ inch at each end. Bake in a hot oven for from 35 to 45 minutes, according to the size, or until they can be easily pierced with a fork.

Tomato and Celery Salad.—Select tomatoes as nearly round as you can find—one for each person. Pour boiling water over them, let them stand a few minutes, and remove the skins. Do not let them stand too long in the hot water, as it will soften them. When they are all skinned, set them aside to get cold. Wash the tender inner stalks of 1 bunch of celery, let them lie in cold water about an hour, then cut into small cubes. Wash 1 head of lettuce and let it lie in cold water, to get crisp. When the tomatoes are perfectly cold, scoop out the inside with a teaspoon, being very careful not to break the outside of the tomato. When done it should be like a cup. Chop fine the pulpy part, that you have taken out, and drain off the juice. Mix this chopped tomato and the celery cubes together; add ½ teaspoonful of salt and half as much mayonnaise dressing as there is tomato and celery.

Mayonnaise Dressing.—Mix together ½ teaspoonful of mustard, ½ teaspoonful salt, a dash of cayenne, and the yolks of 2 eggs, in a bowl. Set the bowl in a pan of chopped ice and add 1 cup of olive oil, very gradually. Stir constantly, and be careful not to add more oil at one time than can be conveniently taken up. As the dressing gets very thick, thin it with 1 tablespoonful of lemon juice, a few drops at a time. You will find it easier to add the oil if it is not too thick. Just before mixing with the tomato and celery, add 1 tablespoonful of vinegar; but do not add it until the last, as it thins the dressing very quickly. Put a few leaves of lettuce on each plate, put the tomato cup in the center and fill with the mixed tomato, celery, and mayonnaise. Do not mix all the mayonnaise with the tomato and celery—reserve a little for the top of the salad.

Mince Meat.—Cook together 2½ pounds of cheap, lean beef and 1½ pounds of suet (which has had the membrane removed) until the meat is tender. Pour off the liquor into a bowl, and let it cool. Chop the meat *fine*. There should be 4 cupfuls of meat when chopped. To the meat add 8 cupfuls of finely chopped sour apples, 2 pounds of raisins (Sultana raisins are best, as they are small and contain no seeds; if you prefer the ordinary raisins they should be seeded and cut in pieces), 1 pound of currants, 1 pound of dates (stoned and chopped), ½ pound of citron cut fine, 1½ cups of good molasses, 3 pints of sweet cider, 3 cups of brown sugar, 1½ cups of granulated sugar, 2½ tablespoonfuls of salt, 1 tablespoonful each of ground cinnamon and allspice, 1½ teaspoonfuls of mace, 2 of cloves, ½ teaspoonful of black pepper, and 1 nutmeg, grated. Last of all, add the cooled liquor. Mix these ingredients well together and let them simmer on the back of the stove for 2½ hours. Remove from the fire and add 1½ cups of brandy and the juice of two lemons and two oranges. When cooking the meat and suet, be careful not to cook it too long, as the meat drops to pieces

and it is very hard to chop the fibers. Put the mince meat into pint glass jars, and screw the covers on tight. One pint is enough for one pie.

Of course it is not necessary to make this full amount, but mince meat, like plum pudding or fruit cake, is improved by standing for some time. Mince meat should be so well blended that the separate ingredients are imperceptible to the taste.

Pumpkin for Pies.—Select a firm, medium sized, deep orange-colored pumpkin. Cut into pieces about the size of your hand; pare and scrape out the seeds and pulpy inside part. Put it on to cook in a granite kettle, with about ½ as much water as there is pumpkin. Let it cook for 6 hours, stirring frequently to prevent its sticking to the bottom of the kettle and burning. When the pumpkin is done, all the water should be cooked away, leaving the pumpkin dry and quite thick. Rub it through a sieve and add 1 cup of good molasses. To every 2 cups of this add 1½ cups of milk, ½ cup of granulated sugar, 1 teaspoonful of salt, 1 teaspoonful of ground cinnamon, 1 teaspoonful of ginger, and 3 eggs slightly beaten.

Crust.—Sift 1½ cups of pastry flour, ½ teaspoonful of good baking powder, and ½ teaspoonful of salt into a bowl. Measure ½ cup of butter and lard mixed; put half of this into the flour, and, with a knife, cut and mix it until there are no lumps, but all is well mixed. To this add as little cold water as will make the flour and shortening stick together; mix very quickly with a knife, not with the hands, as pastry to be good and flaky should be very cold, and the shortening hard, and the warmth of the hands will soften it. Sprinkle a little flour on the pastry board; put the pastry on the board, and with the rolling pin roll out quickly, always from you—one way. Now put the remainder of the shortening in little bits all over the pastry; roll it up and cut into four pieces. Take two of these rolls, put one on top of the other and roll out again. Turn the pastry around, but never roll towards you, and keep it as nearly round as possible.

Mince Pie.—Line a pie pan with the first piece of pastry; pour in 1 pint of mince meat. Trim the pastry off around the edge of the pan; wet the top edge with either cold water or white of eggs. This is to make the two pieces stick together. Roll out the remainder of the pastry in the same way as you did the first; cut three or four little slits in it about ½ inch long. Put it carefully over the top of the pie, pinch the edges together and trim off the part that hangs down. Bake in quite a hot oven, until light brown. If the oven is too slow, the crust will become hard and dry before it is brown.

Pumpkin Pie.—In making pumpkin, custard, or fruit pies, it is foolish to put a crust in the bottom of the pan, as it becomes wet and soggy, and is unfit to eat. Grease the pan well and sprinkle the bottom with fine, dry, bread crumbs; put a strip of pastry about 1½ inches wide around the sides of the pan. Fill nearly full with the prepared pumpkin, stand in the oven and then fill quite to the top. Pumpkin pie, like custard pie, takes from ½ to ¾ of an hour to cook. Do not have the oven too hot, as the pie will then brown before it is thick. Pumpkin and mince pies are better if made a day or two before they are to be eaten.

LIFE'S SYMPHONY.

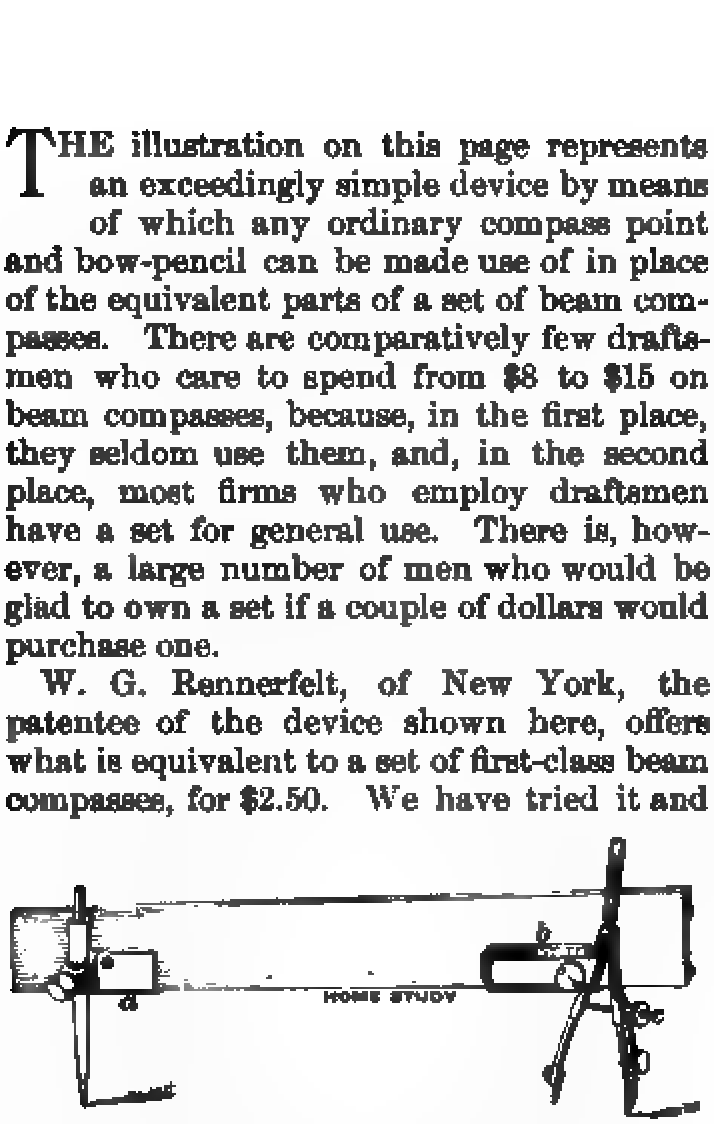
AS THE end of the present century draws near, and we look back upon the great gains that have been made in every branch of science, it is a somewhat sobering reflection that in spite of the many ingenious mechanical appliances accepted and used in the belief that they add to the comfort of living, we are still a restless people, seemingly as far off as ever from the goal of perfect contentment.

The thoughts expressed in the following passage from the writings of William Henry Channing were surely prompted by a realization of the unprofitableness of mere artificial aids to happiness:

To live content with small means; to seek elegance rather than luxury, and refinement rather than fashion; to be worthy, not respectable, and wealthy, not rich; to study hard, think quickly, talk gently, act frankly; to listen to stars and birds, babes and sages, with open heart; to bear all cheerfully, do all bravely, await occasions, hurry never; in a word, to let the spiritual, unbidden and unconscious, grow up through the common. This is to be my symphony.

THE illustration on this page represents an exceedingly simple device by means of which any ordinary compass point and bow-pencil can be made use of in place of the equivalent parts of a set of beam compasses. There are comparatively few draftsmen who care to spend from $8 to $15 on beam compasses, because, in the first place, they seldom use them, and, in the second place, most firms who employ draftsmen have a set for general use. There is, however, a large number of men who would be glad to own a set if a couple of dollars would purchase one.

W. G. Rennerfelt, of New York, the patentee of the device shown here, offers what is equivalent to a set of first-class beam compasses, for $2.50. We have tried it and



find that it is in every respect an excellent substitute for a $10 instrument. Referring to the figure, *a* is a clamp which carries the compass point as shown; *b* is another clamp similar to *a*, but supplied with a jaw which will fit any ordinary bow-pencil or bow-pen leg; fine radial adjustments are made by means of the screw *c*. Draftsmen will appreciate the simplicity of this little device. It should have a large sale. The manufacturers are The Parker Automatic Fire Extinguisher Co., 78 and 80 Cortlandt St., New York City.

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ANNUAL REPORT AND PROSPECTUS OF THE EDUCATIONAL DEPARTMENT OF THE Y. M. C. A. OF NORTH AMERICA. Geo. B. Hodge, Secretary of the International Committee, 3 West Twenty-Ninth street, New York City. The annual report contains a summary of the educational work of the North American Associations for 1898, and the report of the Educational Secretary. The summary shows that during the past year (1897–98) over 25,000 men attended the evening classes conducted in 350 associations; 102 associations took part in the international examination, and 750 certificates were awarded to successful students by the international examiners. The prospectus contains a history of this educational movement, outlines of the course of study, regulations for the standard examinations, examination questions for 1898, etc. From an educational standpoint, the outline of the courses and the examination questions are of particular interest and value. The subjects included are: arithmetic, bookkeeping, business and commercial law, good citizenship, freehand drawing, architectural drawing, mechanical drawing, carpentry, algebra, plane geometry, applied mechanics, hygiene, chemistry, physics, English, and association city council. Those interested in Y. M. C. A. affairs, or in educational work in general, should procure copies of this report and prospectus; price of report, 15c., $1.50 per dozen; of prospectus, 20c., $2.00 per dozen.

CATALOGUE REVIEWS.

BICKFORD DRILL & TOOL CO., Cincinnati, Ohio—successors to The Universal Radial Drill Co., whose complete business they purchased a year or two ago—have recently issued a refreshingly businesslike catalogue of their manufactures, which include upright drills, radial drills, vertical and horizontal multiple drills, horizontal boring and drilling machines, single-column boring and turning mills, and special tools for same. Accompanying the illustrations of these machines are very complete tables of sizes and weights, floor space occupied, best speeds for running, etc., which make the catalogue of much value to machine-tool users.

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THOSE of our readers who were interested by Mr. Turner's article entitled "The Impulse Waterwheel," published in the May number of HOME STUDY MAGAZINE, will

obtain much valuable information from the catalogues of James Leffel & Co., Springfield, Ohio. The "Cascade" (impulse) water-wheel catalogue contains, besides photographs of various wheels made by them, much practical information concerning water-power, such as the measuring of the power of streams, weir dam and miners' inch measurements, etc. There are also extensive tables of size of wheel, head of water, power developed, velocity and quantity of water, number of nozzles, etc. This and the Turbine catalogue, which is of a similar nature, should be in the hands of all who are interested in the subject of water-power.

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THE RIKER ELECTRIC MOTOR Co., 45 York St., Brooklyn, N. Y., have handed us their latest catalogue of electric vehicles. That the "horseless carriage" has come to stay there is no doubt whatever, though possibly dwellers in small towns find this difficult to realize or believe. In our great cities, however, and in European cities, too, electric carriages have already ceased to attract special attention as they noiselessly bowl along the busy streets. In New York, for instance, electric hansoms are to be seen in all parts of the city, and they certainly do not lack patronage, for their speed and comfort, and the uninterrupted view ahead obtained from them, are all greatly in their favor over any other kind of vehicle. The accompanying half-tone represents the Riker electric Victoria for two passengers; the maximum speed of this carriage is 12 miles per hour, and it is capable of running 25 miles per charge; it has three distinct speeds forward, and two backward, and is steered by the front wheels—like a bicycle. The variety of vehicle turned out by this company is worthy of note; those represented by photographic half-tones in their catalogue include tricycle carriages, phaetons, two-passenger and four-passenger traps, four- or five-passenger surreys, and a variety of delivery wagons.

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LAST month we published an article by Carl G. Barth entitled, "The Corliss Valve Gear." We have just received from The Hooven, Owens & Rentschler Co., Hamilton, Ohio, a superb pictorial catalogue of the Hamilton Corliss Engine, of which they are sole makers. This book—the size of which is 14 in. × 9½ in.—contains, in addition to several diagrams and tables, eighteen full-page half-tones of heavy-duty Corliss engines. It is a work of art which should be in the possession of every steam user who wishes to be strictly up-to-date.

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THE NEW PROCESS RAW HIDE Co., Syracuse, N. Y., in their latest catalogue—a very neat little pocketbook of 100 pages—describe and illustrate their patent rawhide pinions and gears (both spur and bevel), bushings, washers, mallets, and chisel handles. Of their new process rawhide they say: "It is the very best quality of steer hide, cured by our patented process. It is applicable to numerous purposes beyond the range of ordinary rawhide, as it may be stained any desired color, will take glue as readily as will wood, and (single thicknesses only) may be embossed or molded into any desired form. By the application of great pressure, and other features of our patented process, the

hide is condensed and all superfluous matter eliminated, leaving it extremely light in weight, yet retaining all its valuable properties." The middle 50 pages of the catalogue consist of a price list of the gear-wheels and pinions kept in stock by the company, the sizes varying from 2 inches to 15 inches in diameter, and from 1 inch to 10 inches width of face. Rawhide gears, being noiseless and requiring no lubrication, are especially adapted for use on high-speed machinery, where noise is objectionable, such as electric-motor cars, roller mills, elevators, machine tools, etc. The strength and durability of rawhide gears is remarkable.

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THE MIANUS ELECTRIC CO., of Mianus, Conn., is making a specialty of electric supplies for the experimentalist. Any kind of material, appliance, or machine—from an electric bell to a gas engine—can be obtained from them, either complete or in part, finished or in the rough. The line of apparatus included in the catalogue is selected with the idea of supplying those of limited means who wish to make electrical experiments at home.

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JONES & LAWSON CO., Springfield, Vermont, publish an 80-page catalogue devoted entirely to the Hartness Flat Turret Lathe, and its work, in which remarkably fine photographic reproductions give some idea of the variety of work that can be turned out by these useful automatic machines. There are full-sized illustrations of a great variety of bolts, studs, nuts, and bushings, of special shapes, together with the time it takes the turret lathe to turn them out. The same concern publishes a supplementary catalogue entitled "Screw Thread," descriptive of the Hartness Automatic Die, designed expressly for use in the flat turret lathe above mentioned. The illustrations in both of these catalogues are as good as any we have seen, and the manner in which the various operations are explained makes them of unusual practical value.

BOOK REVIEW.

BUILDING CONSTRUCTION AND SUPERINTENDENCE. By F. E. Kidder, C. E., Ph. D., Fellow American Institute of Architects, author of the "Architects' and Builders' Pocket Book." Part II. "Carpenters' Work." One vol. 8vo. 524 illustrations. 524 pages. New York: William T. Comstock, 23 Warren street. 1898. Price, $4.00.

Mr. F. E. Kidder, known to the architectural profession through his "Architects' and Builders' Pocket Book," published, two years ago, the first part of a work entitled, "Building Construction and Superintendence," which we highly commended at the time. We now have the pleasure of announcing the appearance of Part II, which is of the same size and general make-up as Part I, but contains 100 more pages and twice as many illustrations.

In Part I, the author described those details of construction usually coming within the province of the mason, and in this volume he deals more especially with the details of all forms of wooden construction, from the rough framing of wooden or brick buildings to finely finished cabinet work. The work is in every sense what may be called a practical one, and the better systems of constructions are intelligently pointed out, as are also the defects of the cheaper and more common forms.

The first chapter is devoted to the building and finishing woods of the United States, and is perhaps the most intelligent and practical treatment of the subject yet placed before the general reader. Following this are four chapters on wood framing; windows and outside frames; outside wood finish, shingle roofs, and the accompanying metal work; and interior woodwork, including furring, interior finish, cabinet work, stairs, flooring, etc.

Chapter VI devotes nearly 100 pages to a description of builders' hardware, showing the difference in the construction and qualities of locks, butts, and other forms of trimmings, and illustrating the principal varieties.

In each of these chapters, the author indicates the special points that should receive attention, and gives warning of the various defects often met with, and the ways in which they may be covered up or concealed by the contractor.

Chapter VII is devoted to heavy framing, illustrating and describing various details of framing usually employed in what may be called heavy buildings.

In Chapter VIII are given forms of specifications as a guide when writing specifications for carpenters' work, including the hardware trimmings, roofing, tinwork, etc. These specifications are admirable examples of explicitness in describing the materials to be furnished and the work to be done, while at the same time they are concise and well arranged.

(483) (*a*) What is a fuse box, and for what is it used? (*b*) What is a high-pressure gate valve, and for what is it used? (*c*) What is the difference between an inspirator and an injector? (*d*) I have a 20-horsepower firebox boiler with which I run a 20-horsepower common slide-valve stationary engine. Will the same boiler supply sufficient steam for a 20-horsepower cross-compound engine, and do the same amount of work, without increasing the boiler pressure or amount of fuel used? Kindly illustrate the fuse box and gate valve.

B. C., Cleves, Ohio.

ANS.—(*a*) A fuse box is a box designed to protect a fuse block or a fused cut-out from the weather, or from hard usage. Fuse blocks to be used in conjunction with boxes are generally of special design, such as illustrated in Fig. 1, which represents a fuse

FIG. 1

box for high-potential circuits. The plug *a*, Fig. 1, is removable and carries the fuse. In a box of this construction, it is almost an impossibility for an arc to be established from one terminal to the other. (*b*) A gate valve is a valve that operates in a manner similar to a sliding gate. Fig. 2 represents such a valve. A high-pressure gate valve is one designed for high pressures, either of water or steam. Fig. 2 is a high-pressure steam gate valve. A water valve is constructed somewhat similarly. (*c*) See HOME STUDY MAGAZINE, June, 1898, Answers to Inquiries, No. 214. (*d*) It should be able to do the same amount of work, with less fuel in the second case than in the first. It is probable that the compound engine is designed for a higher steam pressure than the simple engine. However, unless the steam pressure is very low, say 60 pounds per square inch, the compound engine should be the more economical.

FIG. 2.

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(484) (*a*) If cold water is forced into a new boiler while the latter is hot, will the boiler explode? (*b*) What causes a boiler to explode? Does the cold water crack the plates, or is there a gas inside the boiler which is in some way ignited? (*c*) Are the plates of a boiler as hot as the water in the boiler? (*d*) Is it possible to bear the naked hand on the bottom of a kettle that contains boiling water?

D. E. S., South Bend, Wash.

ANS.—(*a*) When cold water comes in contact with hot plates, it cools them very rapidly and unevenly, the result being that the cooled part of the plate shrinks much faster than the rest, and this either cracks the plate or weakens it so much as to make it unsafe. The boiler may or may not explode, depending on the amount of injury done to the plate, and the steam pressure. (*b*) A boiler explodes for the reason that some part is too weak for the pressure. The weakness may be due to a variety of causes, such as poor material, design, or workmanship, or to injury while in use. There is probably no case in which an explosion is due to gases generated in the boiler, although that theory is held by some. (*c*) If the inside of the boiler is coated with scale, so as to prevent the heat from passing readily to the water, the plates may be cooler than the water if they are exposed to the air, or hotter if exposed to the fire, otherwise there will be very little difference in the temperatures. (*d*) It may be possible if the bottom is coated with soot on the outside. In most cases, however, we think a serious burn would follow such an attempt.

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(485) Three hoisting engineers and I have had quite an argument on the following: Suppose that in a steam pump the diameter of the steam piston is 8 inches, and that of the water piston is 4 inches, would the pump force any water into the boiler if an 8-inch check were placed between the pump and the boiler?

W. H. C., Dugger, Ind.

ANS.—Yes; the pressure that tends to keep the valve shut is equal to the area of its top surface, multiplied by the pressure per square inch in the boiler, and, in order to open the valve and force water through, the pump must produce a pressure per square inch on the under side of the valve which, when multiplied by the area of the under side, will overcome the pressure on the top. With the given dimensions, the pump will easily produce more than the required pressure.

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(486) (*a*) In HOME STUDY MAGAZINE, August, 1898, article entitled "Stresses in a Bicycle Frame," Fig. 6, kindly explain how the point *e* is found. It seems to me as though it would be necessary to know the stress in either *E B'* or *A E'*. (*b*) How can I obtain a copy of the "Instructions of the General Land Office to Surveyors"?

W. E. B., Willink, N. Y.

ANS.—(*a*) The method of locating the points *e* and *e'* is somewhat unusual, owing to the fact that the two lines *b'e* and *e'a*, representing the unknown forces in the force polygon *a b b' c e e' a*, are not adjacent to each other. In constructing the force polygon for the joint *f*, the lines *a b* and *b b'*, representing known forces, are drawn first; then, from the point *b'*, a line *b'e*, of indefinite length, is drawn parallel to

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see contents page.

$B'E$, and from the point a, a line ae' of indefinite length is drawn parallel to AE'. These two lines of indefinite length are to be connected by the line ee', whose length and direction are both known, as it represents the pull in the chain EE', which has been computed. The points e and e' are accordingly determined by drawing the line ee' parallel to EE' and intersecting the lines $b'e$ and ae' in such positions as to be of the proper length between the points of intersection. (*b*) By addressing the Commissioner of the General Land Office, Washington, D. C.

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(487) Please show how to lay out a flare to fit roof as in enclosed sketch, Fig 1.
H. S. J., Portsmouth, Va.

ANS.—The solution to your problem is given by Fig. 2. $ABCD$ is the shape to be laid out; MN denotes the roof, and is drawn at a slope of $4\frac{1}{4}$ ($= 20 - 15\frac{3}{4}$) to 19. The construction is as follows: Produce the sides AD and BC to the point O on the center line, and with O as a center describe the circular arcs DE and AH with radii OD and OA, respectively. Draw the horizontal line AG, and with 3 as a center describe a semicircle $A3G$, which is a view of half of the base of the cone OAG. Divide this half circle into a number of equal parts, say six, and from the points of division 1, 2, etc., draw vertical lines cutting AG in the points 1, 2, 3, etc. Join these last points to the vertex O by the lines $O1$, $O2$, etc., which intersect the roof line MN in the points P, Q, R, S, T. Through these last points draw horizontals cutting OA in the points P'', Q'', R'', etc. Now, on the arc AH lay off $A1'$, $1'2'$, $2'3'$, etc., each equal to one of the equal divisions $A1$ or 12 of the semicircle. Draw the radii $O1'$, $O2'$, $O3'$, etc., and on $O1'$ lay off $1'P' = AP''$, $2'Q' = AQ''$, $3'R' = AR''$, and so on. Through the points A, P', Q', R', S', T', F, draw a smooth curve; then $ADEF$ is the development of one-half of the shape. The other half is, of course, the same.

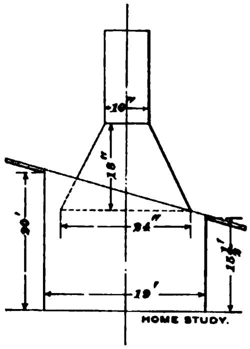

FIG. 1.

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(488) How does the cost, per horsepower, of maintaining a gasoline engine compare with that of running an electric motor, for propelling a small launch? Also, give me some idea of the difference in the first cost.
C. L. S., Seattle, Wash.

ANS.—The gasoline engine will give a horsepower at a cost of 10 cents per day of ten hours with gasoline at 9 cents per gallon, while the same size electric motor will cost \$1.00 to run it the same length of time with power at 10 cents per kilowatt-hour. A 1-horsepower electric launch complete costs anywhere from \$500 to \$1,000, and the same size gasoline launch with a 2-horsepower motor may be obtained for prices ranging from \$165 to \$500.

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(489) Can you give me the name of a book on mechanical drawing, in which the proper method of shading concave and convex surfaces, and such other details of mechanical drawing as require conventional methods of treatment, are clearly explained and illustrated?
E. B. T., Florida.

ANS.—We suggest the following: "Mechanical Drawing" by John S. Reid, \$2.00; "Mechanical Drawing" by Wm. Minifie, \$4.00. These books may be obtained from The Technical Supply Co., Scranton, Pa.

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(490) I desire some information regarding compound marine engines, operated with natural draft. In my locality there are many non-condensing marine engines, in which the exhaust is turned into the stack, thus supplying the boiler with forced draft. Salt water and expensive fuel are continually compelling boatmen to install some form of compound or triple expansion condensing machinery, in reference to which engineers are consulted as to the largest size of cylinders that a boiler of given size will supply, when working with natural draft. I am running a 60″ × 84″ Clyde boiler, with brick back; it has 324 square feet of heating surface, and is fitted with 96 2-inch tubes, 4 feet 10 inches long. The fuel used is fir wood, and there are no grates, the furnace being filled completely when firing. The boiler has a good draft and steams freely, maintaining a working pressure of from 115 to 130 pounds gauge. Take this boiler as an example, and show how to figure the greatest amount of steam it will furnish under natural draft. This having been determined, show how the maximum cylinder areas are arrived at, allowing sufficient steam to work the air and other pumps, all of which are independent. I presume these cylinder areas depend largely upon piston speed; take, therefore, for example, the engine I am now running, the piston of which is 10 inches in diameter, with a 10-inch stroke, and which makes 206 revolutions per minute with 130 pounds of steam,

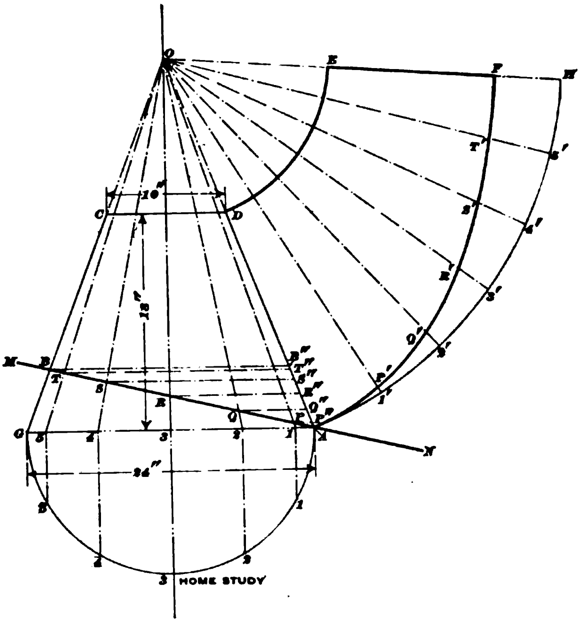

FIG. 2.

cutting off at 5½ inches; the exhaust pipe is 3½ inches in diameter, but is reduced to 2½ inches at the stack.

A. H. C., Washington.

ANS.—The methods used in arriving at a correct solution of your question are too lengthy to admit of explanation in this column. We would recommend you to purchase Seaton's "Manual of Marine Engineering," price $5.00; it may be obtained of The Technical Supply Co., Scranton, Pa.

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(491) (*a*) How much No. 36 wire will it take for the secondary coil, to get a ½-inch spark? (*b*) What is the voltage of a ½-inch spark?

C. M. H., Charlotte, N. C.

ANS.—(*a*) With a properly designed coil, one pound of No. 36 wire should give a spark ½ inch in length. (*b*) Recent experiments have shown that the difference of potential necessary to project a spark across an air gap of one inch is about 54,000 volts. While the voltage required does not vary directly as the distance for all ranges of sparking, still halving the above figure gives what is probably as accurate an estimate of the voltage of a ½-inch spark as can be arrived at. The difference of potential, then, to force a spark across an air gap of ½ inch, is about 27,000 volts.

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(492) I have a small alternating-current dynamo, the armature of which is 2½ inches long by 1½ inches in diameter, wound with about 2,500 feet of No. 36 wire. (*a*) Can I, with this alternator, run a transformer like that described in HOME STUDY MAGAZINE, August, 1898, Answers to Inquiries, No. 335? If so, what would be the dimensions of the coil that would give the greatest advantageous heating power? (*b*) How large a piece of iron could I hope to fuse with such a coil?

R. F. P., Somerville, Mass.

ANS.—(*a*) At a speed of about 1,200 revolutions per minute the machine will generate an E. M. F. of about 100 volts. Its capacity at this speed is about 10 watts, giving a current strength of $\frac{1}{10}$ ampere. The transformer should consist of a core of iron wire 3 inches long, ¾ inch in diameter; the primary coil should be of No. 34 B. & S. double cotton-covered or single-covered, wound with 1,000 turns; the secondary should consist of ten turns of No. 16 B. & S. double cotton-covered wire, wound about the center of the primary coil. All parts should be insulated and shellaced. (*b*) Only a very small piece of iron wire, possibly ½ inch, of No. 20 B. & S. can be fused.

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(493) Can a fish—a black bass, for instance—be drowned in water? Last May we had a dispute here, *A* claiming that a fish can be drowned, basing his opinion on the following extract from an article by Dr. F. Henry Yorke, entitled "Black Bass Fishing in the Wisconsin Lakes," which appeared in the August 27th issue of "The American Field": "Always drown your fish, or nearly so, for then it can be safely and easily brought to the boatside, ready to be taken by the landing net, hooked by the gaff or quickly but gently taken by the gills or eyes with the fingers. The latter process can only be successfully accomplished by practice, the fingers being gently slipped along the fish's back, the thumb and forefinger slipped either under its gills or into the bony eye sockets, according to the size or weight of the fish, the gills being preferable for all kinds of bass. Drowning is simple. A fish, when it opens its mouth under water, takes in a mouthful, its gills being closed; when it shuts its mouth the gills open, and the water pours through them back to its own element, having lost some oxygen and gained some carbonic acid. Now this process of breathing must have for its essential conditions a circulating fluid exposed to the influence of atmospheric air or oxygen in solution. The respiratory apparatus consists essentially of a moist and permeable animal membrane, with the blood vessels upon one side of it, and the air or aerated fluid on the other. The blood and the air or oxygen in solution, consequently do not come into direct contact with each other; but absorption and exhalation take place from one to the other, through the thin membrane which lies between. During the passage of the water through the gills, oxygen is absorbed, which renders them a bright red color, and is carried into the general circulation, carbonic acid gas being discharged. If the fish swallowed the water, which during its rapid passage was forced into its mouth, instead of allowing it to pass out by its gills, it would naturally drown like anything else. And that is what you make it do, for the taut strain of the line held by the rod forces open its mouth to a greater or less extent, the gills being closed in like proportion. By its rapid rushes through the water, the fish in its struggles forces considerable water down its throat, gradually becomes suffocated, finally exhausted, and is easily drawn to the boat." *B* claims that a fish cannot be thus drowned, maintaining that as a fish has no lungs it does not breathe as human beings do, but that, as the gills of the fish pulsate, oxygen from the water is taken into the blood *direct* at the gills, which, he says, are covered by an exceedingly thin membrane, having pores like our skin; at the same time, the fish exhales nitrogen through tubes, discharging it at the nose, and then when the fish is hooked, the mouth opens, the gills close, the source of oxygen is cut off and the fish *smothers* to death, and that the *water* has nothing to do with it. *A* claims that if a fish is put in a wire cage and lowered into his natural home, water, that he will soon die. Can you say, positively, who is right, *A* or *B*?

T. O. C., Cameron Mills, N. Y.

ANS.—We have no direct information in regard to this matter, but we think that a fish *can* be drowned, and we are also inclined to think that the explanation given in the above extract from "The American Field" is essentially correct.

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(494) (*a*) How much 1-inch rope will it take to wrap a pole that is 100 feet high, 1 foot in diameter at the bottom, and 6 inches in diameter at the top? (*b*) How would you remove a person from a live electric wire, if it were impossible to signal to the power house? (*c*) Can you tell me how to analyze bituminous coal? Where can I get a book on the subject?

H. M. MCA., McCartney, Pa.

ANS.—(*a*) An excellent approximate formula for the solution of such problems is given in HOME STUDY MAGAZINE, July, 1898, article entitled "Arithmetical Progressions." The formula is

$$L = \frac{1}{2}\pi n(D + D').$$

In this example we have $n = 1{,}199$, $D = (1 + \frac{1}{12})$ ft., and $D' = (\frac{1}{2} + \frac{1}{12})$ ft. Hence, $L = 3{,}138.97$ feet. (*b*) Wrap some insulating covering about the hands, as thick, at least, as a man's coat. Any rubber fabric is preferable, and, best of all, a pair of rubber gloves. If possible, do not form a circuit through your own body, when disengaging another person from a live wire, as the insulating medium about the hands is apt to slip and bring you into contact with the wire. Before you can receive a shock, a complete circuit must be formed, and you may therefore, if the circuit is a grounded one, stand on an insulating stool, and touch a live wire with impunity. (*c*) The analysis of coal consists in the determination (1) of moisture, (2) of volatile combustible matter, (3) of ash, and (4) of sulphur. The operations are rather simple:

1. *Determination of Moisture.*—About 2 grams of the finely powdered coal are weighed out and dried between watch glasses, at 105°–110°, for one hour, and then weighed again. The loss of weight, divided by the weight of coal taken, and the result multiplied by 100, gives the percentage of moisture in the coal.

2. *Determination of Volatile Combustible Matter.*—About 2 grams of the powdered, undried coal are heated for 3½ minutes over a Bunsen flame, in a platinum crucible, and then immediately, without cooling, for the same length of time over a blast lamp. Cool and weigh. Divide the loss of the weight by the amount of coal used, multiply by 100, subtract the percentage of moisture, and the remainder is the percentage of volatile combustible matter.

3. *Determination of the Ash.*—From 3 to 5 grams of the finely divided coal are heated in a small platinum dish, over a Bunsen flame. Usually the incineration proceeds rapidly. When no particles of carbon are apparent in the ash, allow the dish to cool, and weigh it. The difference between this weight and the last, divided by the weight of the coal taken, and multiplied by 100, gives the percentage of *fixed carbon*. The difference between the sum of the percentages of moisture, volatile combustible matter, and fixed carbon, and 100 is the percentage of ash. The sum of the percentage of fixed carbon and ash is the percentage of coke which the coal will yield.

4. *Determination of Suphur.*—Weigh 1 gram of the finely divided coal, and mix it thoroughly by grinding in a good-sized porcelain mortar, with 10 grams of Na_2CO_3 and 6 grams of KNO_3. Place this mixture in a large platinum crucible, cover the crucible with a lid, and place it on a triangle over a Bunsen burner. Heat the crucible very carefully and raise the heat rather slowly. When the mass in the crucible is in a tranquil state of fusion, run it up on the sides of the crucible, allow it to cool, treat it with hot water, and wash it out into a small beaker. Filter the insoluble matter, acidulate the filtrate with HCl and evaporate to dryness. Redissolve in water, with a few drops of HCl, filter the dilute filtrate to about 500 cubic centimeters, heat to boiling, and add 10 to 20 cubic centimeters solution of chloride of barium. Allow the precipitated sulphate of barium to settle, decant the clear, supernatant fluid through a felt on a Gooch crucible, heat the precipitate with a solution of acetate of ammonium, transfer it to the filter, wash well with hot water, dry, ignite and weigh as $BaSO_4$, which, multiplied by .1373, gives the weight of S. We can recommend to you the following books: Fresenius' "Quantitative Analysis," Clairn's "Quantitative Analysis," "The Chemical Analysis of Iron," by Blair, and "Notes on Metallurgical Analysis," by Nathan Lord. All these books may be obtained through The Technical Supply Co., Scranton, Pa.

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(495) (*a*) In making a sewage connection with a cesspool, will the ordinary vent pipe which is carried out through the roof of the house give sufficient ventilation for the odors from the cesspool itself, or should a separate pipe be used for this purpose? Of what size should this last pipe be? The cesspool is not lined, and, as the soil is light and sandy, I believe the accumulation of gas will be slight. (*b*) I am informed that the formula used for the determination of the diameter of standard wood screws is $D = .01325\,n + .056$ inch. When D = diameter, what is n, and on what is the formula based?

X., St. Augustine, Fla.

ANS.—(*a*) Use a separate pipe for this purpose, and run it up a tree, if one is conveniently near. Four-inch pipe is considered to be large enough for an ordinary small cesspool. (*b*) In the above formula, D = the diameter in inches, and n = the standard gauge number of the screw. The smallest wood screw regularly made, No. 0, is .056 inch in diameter, and from that up to No. 30 the diameter increases .01325 inch for each number. Thus, by multiplying the rate of increase (.01325) by the gauge number of the screw, and adding to the product the diameter of the smallest screw (.056), we obtain the diameter in inches corresponding to the gauge.

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(496) (*a*) Is the amount of power required to propel a bicycle, geared to 70 inches by means of 8-tooth and 20-tooth sprockets, the same as that required for the same gear—namely, 70 inches—when obtained by using 10-tooth and 25-tooth sprockets, the two bicycles being in every other respect identical? (*b*) If, in the first of the above bicycles, the required crank pressure is 100 pounds, what will be the crank pressure to propel the same wheel geared to 77 inches, by means of 8-tooth and 22-tooth sprockets? (*c*) How does the addition of teeth to the sprockets affect their efficiency?

J. B. S., Scranton, Pa.

ANS.—(*a*) and (*c*) Experiments have shown that the efficiency of the sprocket depends somewhat upon the number of teeth, the greatest efficiency being given by the largest sprockets. In the experiments reported by Mr. J. G. D. Mack (Trans. A. S. M. E., Vol. XVIII, p. 1,071), the efficiencies for 7-, 8-, and 9-tooth rear sprockets, with the same large sprocket, were as follows: 7-tooth, 89.7; 8-tooth, 91.5; 9-tooth, 93.4. Theoretically, the larger sprockets are preferable, because the chain moving, as it does, with greater velocity, is under a less tension, and therefore exerts less pressure upon the teeth; also, the pressure on the bearings due to the chain tension is reduced. Probably in actual use the size of the sprocket has little influence on the power required to propel the bicycle, but whatever difference exists is doubtless in favor of the large sprocket. (*b*) $100 \times \frac{77}{70} = 110$ pounds, neglecting the slight difference in the efficiencies of the two sprockets.

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(497) Enclosed is a sketch of an engine shaft, Fig. 1. Kindly determine (*a*) the bending stresses due to the weight of the shaft, flywheel, and armature; (*b*) the twisting stresses due to the rotation of the parts; and (*c*) the combined bending and twist-

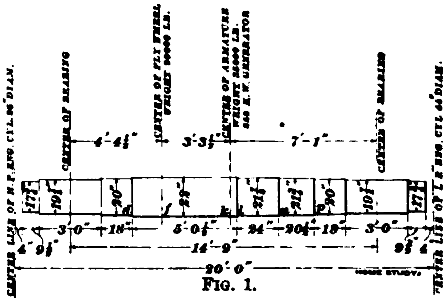


FIG. 1.

ing stresses. The weight of the flywheel is 90,000 pounds; of the armature, 35,000. The engine is a horizontal cross-compound with 26-inch and 44-inch cylinders, 48-inch stroke, 80 revolutions per minute, with 150 pounds gauge pressure.

J. R. C.

ANS.—(*a*) In order to compute the bending stresses, it is necessary to calculate the weight of the shaft. In a shaft of such a large size, the iron, when compacted by hammering, will probably weigh about 480 pounds per cubic foot. On this basis, the weight of a solid bar of circular cross-section one foot in length will be 2,618 d^2, where d is the diameter of the section. In Fig. 2 are given the weights of short portions into which the shaft is divided for the purpose of computing the bending moment. The weight of each such portion is considered to be concentrated at the center of its length, which in no case exceeds 12 inches. A sufficiently close approximation would probably be obtained from a less number of divisions. The weights of those portions of the shaft resting in the bearings are not considered. The weights of the cranks and portions of the connecting-rods, if known, should be included in the weights of the cantilever ends of the shaft. The weights of the flywheel and armature are each combined with that of the portion of the beam to which it attaches; no advantage would be gained by computing separately the bending moments due to these. The amount of each

reaction is determined by taking the moments of all the weights about the other reaction. Having determined thus the values of the reactions, the bending moment at any section can be easily computed; it is equal to the algebraic sum, or resultant, of the moments of the forces on one side of the section about any point in the section, giving opposite signs to moments which tend to produce rotation in opposite directions. As the bending moment increases from the left-hand bearing toward the flywheel, and from the right-hand bearing toward the armature, it is only necessary to compute it for each of the varying sizes, at the section adjacent to the next larger size, and at the flywheel and armature for the portion of uniform size, that is, it is necessary to compute the bending moment at the sections d, f, k, l, n, and p, only. From the formula

$$M = \frac{S I}{c} = \frac{S \pi d^3}{32},$$

in which M = bending moment;
S = extreme longitudinal fiber stress;
and d = diameter,

we have $$S = \frac{32 M}{\pi d^3}.$$

By computing the bending moments and applying this formula, we get 3,960, 4,314, 4,005, 3,873, 2,824, and 2,344 pounds for the extreme longitudinal stress at the sections d, f, k, l, n, and p, respectively, due to the bending moment. (*b*) Assuming that the distribution between the high- and low-pressure engines is such that the effective piston pressure of the high-pressure engine is 110 pounds per square inch, and that of the low-pressure engine, including atmosphere, is 60 pounds per square inch, assuming, also, that the length of the connecting-rod is six times that of the crank, or, $6 \times 24 = 144$ inches, and that the total power exerted by each engine is consumed in turning the armature, neglecting any possible effect of the flywheel; we have for the twisting moment T, at the center of the shaft, due to the high-pressure engine,

$$T = 110 \times .7854 \times 26^2 \times 1.0138 \times 24 = 1{,}421{,}000 \text{ inch-pounds},$$

and for that of the low-pressure engine,

$$T = 60 \times .7854 \times 44^2 \times 1.0138 \times 24 = 1{,}849{,}800 \text{ inch-pounds},$$

The value $1.0138 = \frac{\sqrt{144^2 \times 24^2}}{144}$ is the ratio of the maximum crank pressure to the corresponding piston pressure, it being assumed the full piston pressure is exerted when the connecting-rod and crank are perpendicular to each other. The extreme shearing stress due to this twisting moment is found by the formula

$$T = \frac{S_s J}{c} = \frac{S_s \pi d^3}{16},$$

from which $S_s = \frac{16 T}{\pi d^3}$. By applying this formula to the twisting moments just obtained, the shearing stress is found to be 905, 679, 885, 900, 916, and 1,178 pounds at the sections d, f, k, l, n, and p, respectively (*c*) The resultant S_r of the combined longitudinal and shearing stresses is found by the formula

$$S_r = \frac{S}{2} + \sqrt{S_s^2 + \frac{S^2}{4}}.$$

By applying this formula, the resultant stresses are found to be 4,157, 4,418, 4,192, 4,072, 3,095, and 2,834 pounds at the sections d, f, k, l, n, and p, respectively.

* * *

(496) (*a*) In HOME STUDY MAGAZINE, March, 1896, article entitled "Leveling," there is, on page 72, the formula $C = \frac{D^2}{1.75}$. I do not understand how to use it; please explain. (*b*) In surveying or running a line around one-fourth of the circumference of a sphere 25,000 miles in diameter, what would be the sum of the differences between the true and the apparent elevations? (*c*) What would be the effect on the hauling capacity of a locomotive, if the diameter of the driving wheels was increased from 62 inches to 72 inches, all other things remaining as before? H. L. B., Porkersburg.

ANS.—(*a*) See HOME STUDY MAGAZINE, May, 1896, article entitled "A Level Line." The formula referred to gives the correction for the earth's curvature and ordinary atmospheric refraction, to be added to the elevation of a point as obtained by sighting upon it with a leveling instrument, in order to determine its true elevation. The distance sighted is to be expressed in miles. For example, suppose a leveling instrument was leveled up and sighted at a point .7 of a mile distant. The line of sight at the distant point would be at the distance $\frac{.7^2}{1.75} = .28$ of a foot *above* its elevation at the instrument, making the *apparent* elevation of the distant point .28 of a foot *below* its true elevation. Hence, it is necessary to add this amount to the elevation of the distant point, as determined by sighting the leveling instrument. (*b*) This would depend largely upon the character of the atmosphere of the sphere with respect to refraction, and, as we have no knowledge concerning the atmospheric conditions of any sphere of such diameter, we are unable to say. In running a line of levels any distance upon the earth's surface, there will be no theoretical error due to curvature and refraction if the backsight and foresight are made equal for each setting of the instrument. (*c*) Assuming that the capacity of the boiler is ample, and that there is sufficient weight on the driving wheels to give necessary adhesion, the hauling capacity will depend directly on the tractive force exerted by the engine; and anything that affects the value of the tractive force will produce a corresponding effect in the hauling capacity of the locomotive. The average tractive force exerted

through one revolution of a high-pressure two-cylinder locomotive is given by the formula

$$T = \frac{d^2 S P}{D},$$

where T = tractive force in pounds;
d = diameter of cylinder in inches,
S = length of stroke in inches.
P = mean effective pressure in pounds per square inch;
D = diameter of drivers in inches.

The tractive force T, therefore, is equal to the fraction $\frac{d^2 S P}{D}$, and, if the diameter of the drivers is increased, all other things remaining as before, it will only affect the denominator of the fraction. That is, increasing the diameter of the drivers increases the denominator of the fraction and decreases the tractive force, and, therefore, the hauling capacity of the locomotive.

* * *

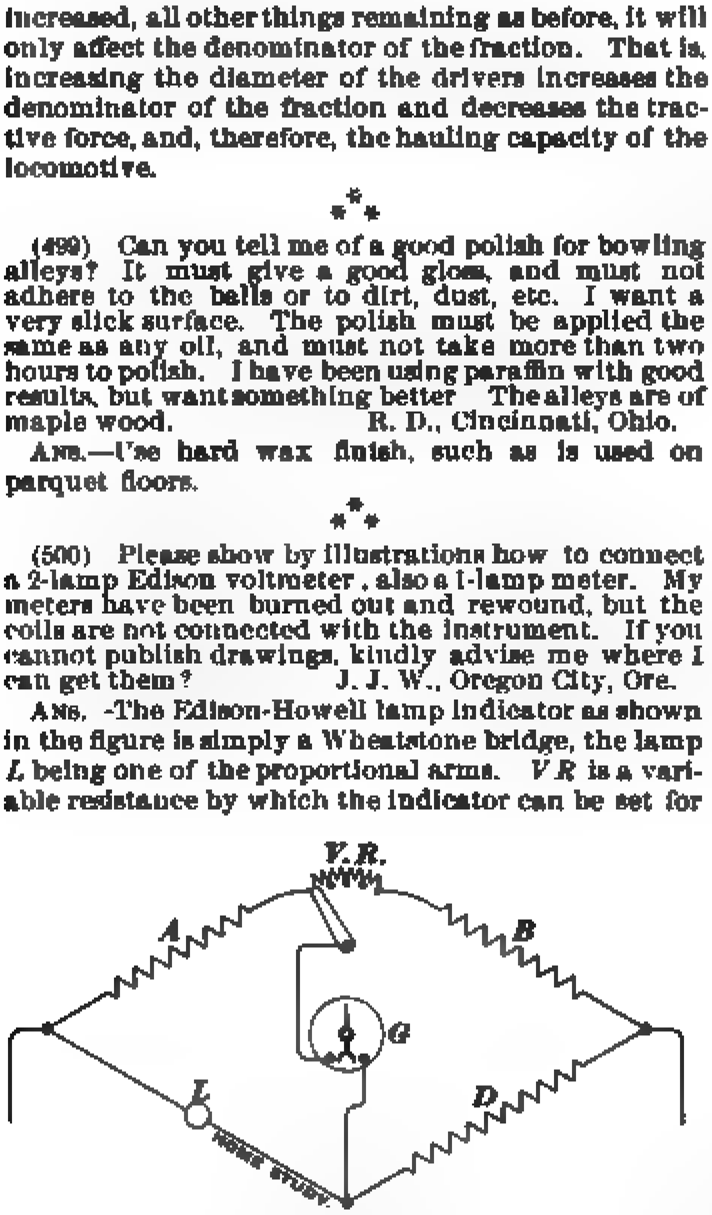
(499) Can you tell me of a good polish for bowling alleys? It must give a good gloss, and must not adhere to the balls or to dirt, dust, etc. I want a very slick surface. The polish must be applied the same as any oil, and must not take more than two hours to polish. I have been using paraffin with good results, but want something better. The alleys are of maple wood. R. D., Cincinnati, Ohio.

ANS.—Use hard wax finish, such as is used on parquet floors.

* * *

(500) Please show by illustrations how to connect a 2-lamp Edison voltmeter, also a 1-lamp meter. My meters have been burned out and rewound, but the coils are not connected with the instrument. If you cannot publish drawings, kindly advise me where I can get them? J. J. W., Oregon City, Ore.

ANS.—The Edison-Howell lamp indicator as shown in the figure is simply a Wheatstone bridge, the lamp L being one of the proportional arms. $V R$ is a variable resistance by which the indicator can be set for



any voltage. A, B, and D are fixed resistances. The burned out coils should necessarily be of their former resistance. G is the galvanometer whose needle points to "high" or "low," as the case may be, due to the variation in resistance of the lamp L, whose brightness varies as the voltage, and whose resistance varies inversely as this factor. The second lamp is only for testing purposes, and should not be left in circuit.

* * *

(501) Please give a diagram of the Reynolds-Corliss valve. R. F., New Orleans, La.

ANS.—We advise you to write to the manufacturers, The Edward P. Allis Co., Milwaukee, Wis.

* * *

(502) What will be the length, diameter, and ampere-turns, etc. of a solenoid and core that will lift a weight of 5 pounds a height of ½ inch? A. S., Matawan, N. J.

ANS.—The rules and formulas for performing this calculation may be found in HOME STUDY MAGAZINE, November, 1897, article entitled "The Design of Hoisting Magnets." A magnet to fulfil the above conditions should be made similar in pattern to that shown in the figure. The proportions should be as follows: cores of magnet, ⅝ inch in diameter; length of cores, 3 inches; distance between centers, 2¼ inches; length of bobbins, 2½ inches; yoke, ⅝ in. × ⅝ in. × 3¼ in. If the armature is to be hinged, as in the figure, the holes should be longer in one direction than in the other, in order not to bind. If the armature is to receive a straight pull, and is not hinged, the holes may be circular, and ¾ inch in diameter. The armature should be 3¼ in. × 1 in. × ½ in. The winding is to consist of two bobbins, each wound with 900 turns of No. 21 B. & S. double cotton-covered wire. The windings are to be connected in series, when a current of a strength of 1 ampere will be required.

* * *

(503) Is the tonnage of a vessel the same as the displacement; that is, if the capacity of a vessel is 20 tons, is her displacement 20 tons? H. S. 964.

ANS.—No, displacement and tonnage are two different things. Any object floating in water displaces, or dislodges, a volume of water, and the weight of the displaced water (which is equal to the floating object) is called the *displacement*. A glance at a tonnage certificate or a register of shipping for any vessel shows three distinct tonnages, namely, *register*, *under-deck*, and *gross*. Register tonnage is a number having no dependence upon the internal capacity as a whole, but is modified by the arrangement of the vessel; hence it does not give any idea of the size of a vessel. Thus, an ordinarily proportioned vessel 250 feet long may have a register tonnage of 700, and another of identical proportions may have a registered tonnage of only 300, and yet both vessels may have equal displacements. The under-deck tonnage is the total tonnage up to the upper deck, in all ships which have less than three decks, and to the second deck from below in all other ships, and is the first part of the vessel measured for tonnage. Gross tonnage comprises the under-deck tonnage, together with all enclosed structures, such as poops, bridges, forecastles, spar decks, awning decks, raised quarter decks, deck houses, engine and boiler casings, skylights, etc. One ton of gross tonnage is equal to 100 cubic feet of capacity, and is the only tonnage that may convey some idea of the entire internal capacity of a vessel.

* * *

(504) (*a*) Please tell me how to make the molds for a flywheel of 12 inches diameter. (*b*) At about what number of revolutions per minute should a 14-inch 4-bladed propeller be driven, to propel a common rowboat at the rate of about 7 miles per hour in still water? F. C., Kalispell, Mont.

ANS.—(*a*) The pattern for the rim of the flywheel should be built up out of segments, well doweled and glued together. The arms may form part of a segment, care being taken that the grain of the wood runs lengthwise of the arm. After the hub (in which the grain of the wood should run axially) is glued to the arms, the pattern is chucked in a lathe and turned up to the required shrink rule dimensions.

The arms are then finished by hand and the pattern coated with shellac. To mold it, it is placed into the lower half (the cope) of a molder's flask; green sand is tightly rammed around it and some flour dusted over the sand. The top part of the flask (the drag) is then put in position and rammed full of sand. The drag is now lifted off, the pattern removed, a gate cut for the entrance of the metal, and the mold properly vented to allow the air to escape when pouring the metal. The cope and drag are next placed together, the dowel-pins in them insuring their correct relative positions. The drag is then weighted down and the mold is ready for pouring. (*b*) Let S = speed of vessel in miles per hour;
P = pitch of propeller in inches;
L = percentage of slip of propeller.
Then, the revolutions per minute may be found from the following formula:

$$\text{R. P. M.} = \frac{S}{5 \times P \times \left(\frac{100 - L}{100}\right)}.$$

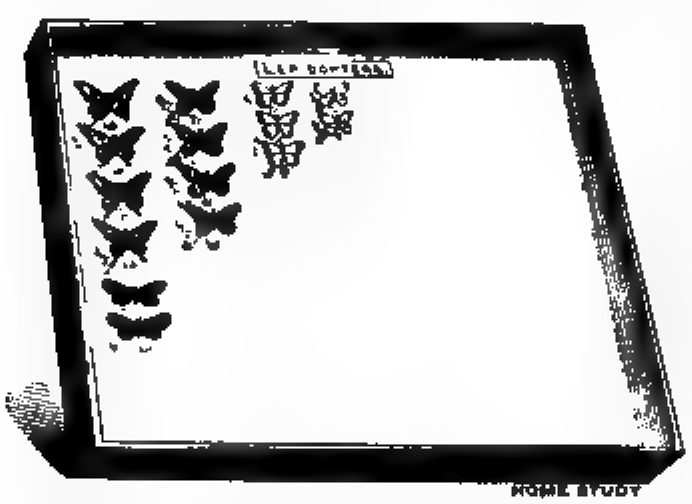
Assuming a slip of 20 per cent., and substituting values, we get

$$\text{R. P. M.} = \frac{5{,}280 \times 7}{5 \times 14 \times \left(\frac{100 - 20}{100}\right)} = 660.$$

***

(505) Kindly let me know what methods are generally used by entomologists in arranging and grouping specimens in the cabinet.
T. J. L., Toronto, Ont.

ANS.—The permanent arrangement of specimens in cabinets and boxes will vary somewhat with the nature of the insects. The almost universal custom of collectors is to arrange the specimens in vertical columns. Beetles which belong to the order *Coleoptera* are generally arranged horizontally, allowing from 1½ inches to 3 inches width between the columns. In the case of butterflies and moths comprising the order *Lepidoptera*, and also in the orders *Orthoptera*, *Hymenoptera*, *Odonata*, and *Diptera*, they are arranged in vertical columns, as shown in the annexed figure. In spacing or dividing insect boxes into columns for the arrangement of specimens, a good plan is to draw fine parallel vertical lines, at regular distances, with a medium pencil, this will not materially disfigure the box. The appearance of the collection will largely depend on the care used in the alinement of the specimens, both vertically and horizontally. It is advisable to have at least

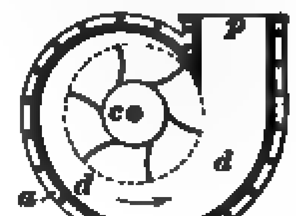


four or five specimens of a species, which, entomologically speaking, constitute a set. The collector, however, should not limit the number of his specimens to four or five, as it is well to have a large number of duplicates to represent the sexes, the varieties, and the geographical distribution. Space should be left for the subsequent insertion of species not at present in the collector's possession, and also for new species. This will avoid the rearrangement of the entire collection at brief intervals. The horizontal arrangement may be used for economic and biologic displays, which include pinned specimens, alcoholic material illustrating the work, and the different stages of the insect, the parasitic and predaceous enemies.

***

(506) Please explain the principle of the centrifugal pump, and show the mechanism of one of the largest patterns. Also give the mathematical work necessary in ascertaining the efficiency, size required, etc. For instance, what size, and how many would it take to remove 2,000,000 gallons of water in 1½ hours? What is the largest safe head? Give the cheapest arrangement of a number of such pumps, and state how they may best be connected with the source of power. H. H. H., Newport News, Va.

ANS.—A centrifugal pump consists of a hollow casing *a*, in which is placed a wheel or disk carrying



a set of curved vanes and rigidly keyed to a shaft *c*. The vanes are so placed in the casing that there is a passage *d d* surrounding them, this passage being just wide enough at one side of the casing to give sufficient clearance to the blades, and enlarging gradually until it opens into the discharge pipe *p*. The casing also has an opening *e* on the center line of the shaft; this opening connects with the suction pipe of the pump. In the case of large pumps it is usual to provide two inlet openings, one on each side of the casing. The theory of the action of the pump is briefly as follows: The vanes are rapidly rotated by means of the shaft, thus imparting a rotary motion to the water between them, and developing the so called *centrifugal force*, which carries the water through the passages between the vanes and discharges it into the passage *d d* with a velocity sufficient to overcome the pressure due to the head under which the pump must discharge. The principal features to be considered, in order to produce a successful design for a centrifugal pump, are *first*, the area of all passages must be sufficient to secure a low velocity of flow, *second*, the passages must be as smooth, uniform, and direct as practicable, *third*, the form of the vanes must be such that, when running at the proper speed, they will receive the water without shock and deliver it at an absolute velocity sufficiently great to enable it to overcome the pressure due to the head against which the pump must discharge. There is a difference of opinion among engineers in regard to the best form to give the vanes, but some of the most reliable authorities seem to prove that blades curved to circular arcs, and meeting the outer limiting circle in a nearly radial direction, as shown in the figure, give the best results. The conditions fixing the radius of the curve are the angles which the ends of the blades make with tangents to their limiting circles at the points of intersection of the blades with the circumference, and these angles are in turn fixed by the velocity of rotation of the vanes, the velocity with which the water enters and leaves the passages between the vanes, and the velocity required to overcome the head of discharge. We cannot give the space in the

Answers to Inquiries columns for a complete outline of the different steps involved in the design of a centrifugal pump for any given purpose. We advise you to consult a reputable builder in regard to the installation to which you refer. Single pumps have been built with a capacity greater than that required to do the work you specify; a special study of all the conditions would be required in order to ascertain the best number and arrangement of pumps for your purpose. Centrifugal pumps are most efficient when working under moderate heads, the efficiency in most cases falling off quite rapidly for heads above 20 feet. Pumps working with a total lift of nearly 50 feet are, however, giving good results, and by a system of compounding, using a series of pumps, one discharging into the following, they can be made to force water to a considerable height.

***

(507) (*a*) Please explain why a stone, dropped from a moving train, strikes the ground vertically under the point from which it is dropped. (*b*) Does the velocity of the crosshead of an engine vary? If so, why? (*c*) What is color, scientifically considered? (*d*) What lead should a valve have to give 2 inches of compression? Would a change in the steam pressure necessitate a change of lead? (*e*) What is a 10-per-cent. gradient equal to, in feet? (*f*) What is the radius of a 1-degree curve? (*g*) In what country did the barber pole originate, and when? (*h*) In balloon practice, what temperature and weight of air are calculations based on?

H. E. McC., No. Platte, Neb.

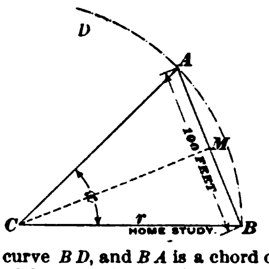
ANS.—(*a*) Before the stone is dropped, it has, of course, the same velocity as the train. When it is dropped, it moves vertically downwards; but, at the same time, it moves forward, according to the law of inertia, with the same velocity it had when it was dropped, the result being that the stone and the point of the train from which it was dropped move forward at the same rate, so that the stone is constantly under that point. This, however, takes place only when the velocity of the train is uniform. If the velocity is increasing, the stone will fall behind the point in question; if the velocity is decreasing, the stone will fall ahead. (*b*) As the crosshead is constrained, by its connection with the crankpin, to move back and forth, it is obvious that it cannot have a constant velocity. Its velocity at the beginning and at the end of each stroke is *o*; then it increases to a certain limit, and again decreases to *o*. If at any moment the crank angle (that is, the angle between the crank arm and the axis of the cylinder) is x, and the velocity of the crankpin is v, the velocity u of the cross head is

$$u = v\sqrt{1-\frac{r^2}{c^2}\sin^2 x}\left(\frac{r}{2c}\sin 2x + \sin x\sqrt{1-\frac{r^2}{c^2}\sin^2 x}\right),$$

where r = radius of crank arm, and c = length of connecting-rod. Usually, the ratio $\frac{r}{c}$ is very small and its square may be neglected. In such a case,

$$u = v\left(\frac{r}{2c}\sin 2x + \sin x\right).$$

(*c*) Light is supposed to be a vibratory motion of the ether, caused by the vibratory motion of the molecules of bodies. The color of a body, so far as our sensation of it is concerned, depends on the impression made on us by the vibrations of the ether, transmitted to the brain through the retina, which impression depends upon the special nature of the body, that is, upon the way in which the body transmits ether vibrations. All bodies do not transmit such vibrations in the same manner—hence, the variety of colors. (*d*) The inside lap, not the lead, influences the compression. A change in the steam pressure does not require a change of lead. (*e*) A gradient of ten per cent. means a rise (or a fall, as the case may be) of 10 *units of length* in a distance of 100 *units of length*, the rise (or fall) being, of course, measured vertically, and the distance horizontally. If the unit of length employed is 1 foot, this gradient means a rise (or fall) of 10 feet in 100 feet; but we may change our unit at pleasure, making it 1 mile, 1 inch, etc., and then our grade of 10 per cent. will mean a rise (or fall) of 10 miles in 100 miles, or 10 inches in 100 inches, etc. A gradient is a *ratio*, and does not depend upon the nature of the unit used. (*f*) The degree of a curve is expressed by the number of degrees subtended by a chord of 100 feet. Thus, in the accompanying cut, if C is the center of the curve BD, and BA is a chord of 100 feet, the degree of the curve is x, the latter letter denoting the angle ACB, subtended by the chord AB. Knowing the degree of a curve, that is, x, its radius r is easily found by solving the right triangle CMB, which gives:



$$r = BM \div \sin \tfrac{1}{2}x = 50 \div \sin \tfrac{1}{2}x.$$

In the case of a 1-degree curve, we have $x = 1°$, $\frac{1}{2}x = 30'$, and

$$r = 50 \div \sin 30' = 5{,}730 \text{ ft., nearly.}$$

(*g*) The Encyclopedia Britannica gives the following information: "In 1745, barbers and surgeons were separated into distinct corporations by 18 George II, c. 15. * * * The barber's sign consisted of a striped pole, from which was suspended a basin. * * * The fillet around the pole indicated the ribbon for bandages around the arm, in bleeding, and the basin the vessel to receive the blood." In "Things Not Generally Known," by D. A. Wells, the following is given: "The barber-surgeon was formerly known by his pole at his door. The pole was used by the barber-surgeon for the patient to grasp in blood-letting, a fillet or bandage being used for tying his arm. When the pole was not in use, the tape was tied to it, and twisted around it; and thus both were hung up as a sign. At length, instead of hanging out the actual pole used in the operation, a pole was painted with stripes around it, in imitation of the real pole and its bandages—hence, the barber's pole." The above is all the information we have on the subject. (*h*) Temperature, 62° F.; weight, .076097 lb. per cu. ft.

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(508) (*a*) How is the absolute tensile strength of a steam boiler found? (*b*) What is the United States government rule for determining the safe working pressure for a steam boiler? Is this rule the one boiler inspectors use? (*c*) What is a coordinate, an ordinate, and an abscissa? Explain by diagrams. (*d*) Can you explain why more water will run through a pipe of given dimensions, if it starts from the supply with a pipe of larger dimensions? (*e*) When water is forced through a nozzle, is its pressure increased? If so, why? (*f*) If a supply of water, having a head of 17 feet, is carried two-thirds of the entire distance in a 1-inch pipe, and the other third in a $\frac{1}{2}$-inch pipe, will as much water be delivered at the end as there would be if the pipe were 1 inch throughout the entire length? (*g*) How does an injector force water into a boiler?

L. P. H., Peterboro, N. Y.

ANS.—(*a*) We do not know what you mean by "absolute tensile strength of a steam boiler." The tensile strength of the steel from which a boiler is made is found by pulling a carefully measured bar in a machine which weighs the load required to break the bar. The tensile strength per square inch is found by dividing the total load required to break the bar by the area of its cross-section in square inches,

before breaking. (*b*) The rules given by the United States statutes are as follows:

For Shell Plates.—

Let

D = diameter of boiler in inches;

P = working pressure in pounds per square inch;

t = thickness of plate in inches;

T = lowest tensile strength in pounds per square inch, stamped on any plate used in the boiler.

Then, for single riveting,

$$P = \frac{t \times 2 \times T}{D \times 6}$$

For double riveting, add 20 per cent. to this value of P.

For Flat Plates.—

Let

P = working pressure in pounds per square inch,

p = greatest pitch of staybolts in inches;

t = thickness in sixteenths of an inch;

C = a constant to be taken from the following table:

C = 112 for plates $\frac{7}{16}$ inch thick and under, fitted with screw staybolts and nuts, or plain bolt fitted with single nut and socket, or riveted head and socket.

C = 120 for plates above $\frac{7}{16}$ inch thick, under same conditions.

C = 140 for flat surfaces where the stays are fitted with nuts inside and outside.

C = 200 for flat surfaces under the same conditions, but with the addition of a washer riveted to the plate, the thickness of the washer being at least one-half of the thickness of the plate, and of a diameter equal to $\frac{3}{4}$ pitch.

Then,
$$P = \frac{C \times t}{p^2}.$$

Loads Allowed on Stays.—Braces and stays shall not be subjected to a greater stress than 6,000 pounds per square inch.

Boilers subject to United States goverment inspection must conform to these rules. In other cases inspectors use rules prescribed by the boiler insurance companies or other organizations for whom they work. (*c*) In analytical geometry two intersecting straight lines, as $x\,x'$ and $y\,y'$ Fig. 1, are called *coordinate axes*, the line $x'\,x$ being called the *axis of*

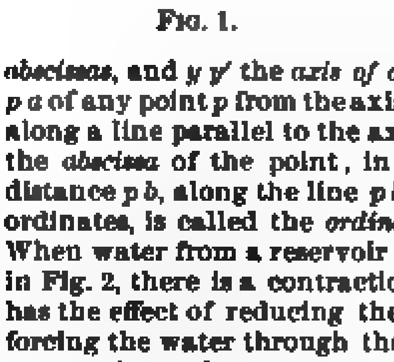

FIG. 1.

abscissas, and $y\,y'$ the *axis of ordinates*. The distance $p\,a$ of any point p from the axis of ordinates, measured along a line parallel to the axis of abscissas, is called the *abscissa* of the point, in a similar manner, the distance $p\,b$, along the line $p\,b$, parallel to the axis of ordinates, is called the *ordinate* of the point p. (*d*) When water from a reservoir enters a pipe, as shown in Fig. 2, there is a contraction of the stream which has the effect of reducing the pressure available for forcing the water through the pipe. The amount of contraction and consequent reduction of flow depends on the velocity with which the water enters the pipe. By making the pipe larger at the entrance, the velocity and consequent contraction are reduced, leaving a greater proportion of the pressure available for overcoming the friction of flow through the pipe. The loss of pressure due to contraction can be obviated by enlarging the end of the pipe into a bell-shaped opening, as shown in Fig. 3. (*e*) When water is forced through a nozzle, the pressure in the pipe leading to the nozzle is absorbed in giving the water the velocity with which it leaves the nozzle. The water in the pipe has a low velocity, with a considerable pressure; in passing through the nozzle its velocity is increased but the pressure is decreased, and, as the water leaves the nozzle, the only pressure to which it is subjected is that of the atmosphere, all the pressure existing in the pipe having been absorbed in giving it its velocity. (*f*) No. (*g*) See HOME STUDY, September, 1896, article entitled "The Injector."

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(509) I want to rig up a small waterwheel for running a lathe. I can make use of the city water, running from a pipe 1 inch in diameter. What would be the best kind of waterwheel to use, and of about what dimensions should it be?

G. G., Long Meadow, Mass.

ANS.—The best motor for your purpose would probably be an impulse wheel similar to the one described in HOME STUDY MAGAZINE, May, 1898, article entitled "The Impulse Waterwheel." The best dimensions depend on a number of conditions, the most important of which is the pressure of the water, which you have not given. Unless the pressure is considerable, the amount of power you can get from a 1-inch pipe will be small. You can get much useful information in regard to such motors as you would need by writing for the motor catalogues of the following concerns: The Pelton Water Wheel Co., 143 Liberty St., New York; The American Impulse Wheel Co. of New York, 120 Liberty St., New York; The Backus Water Motor Co., Newark, New Jersey; and James Leffel & Co., Springfield, Ohio.

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(510) Kindly give me the name of a book in which information is given regarding (*a*) the repairing of steam boilers, and (*b*) the setting up of stationary engines.

E. C., Nebraska.

ANS.—(*a*) Ford's "Boiler Making," price $1.00, and Wilson's "Steam Boilers," price $2.50, are the nearest we can advise. (*b*) Usher's "Modern Machinist,"

FIG. 3.

price $2.50. All three of these books can be obtained from The Technical Supply Co., Scranton, Pa.

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(511) (*a*) Where can I obtain a copy of the rules of the Board of Fire Underwriters on electric-light wiring? (*b*) Do you think it is possible for one who understands electric-light wiring, but knows nothing of the Underwriters' Rules, to wire a building so that it will pass an examination, using his own judgment as to the size of wire, fuses, cut-outs, etc.?

J. K., Jersey City, N. J.

ANS.—(*a*) Address any fire-insurance company in your vicinity and state your wants. (*b*) The rules formulated by the Board of Fire Underwriters were the subject of a great deal of attention and discussion by the Board, and it is not likely that you can

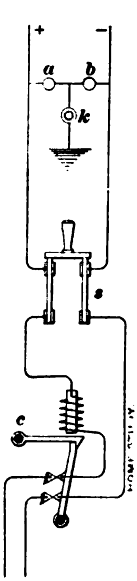
employ just the proper sizes of wire, fuses, etc., and wire a building in accordance with the above rules, without being acquainted with them. The fire department and the local electric-lighting company will, probably, each insist that you follow the Underwriters' Rules.

***

(512) (*a*) Can blueprints be made from pencil drawings? If so, what kind of paper should the drawing be made on, and what kind of blueprint paper is best? (*b*) On an electric crane, where all the motors are in parallel, how should a circuit breaker be connected—on the negative or on the positive wire? (*c*) How should a lamp be connected on the same crane, so as to detect a ground? (*d*) How should a solenoid be wound for operating a brake on a 220-volt line of 50 amperes?

K. W., Sharpsburg, Pa.

ANS.—(*a*) Yes. Use a black pencil on bond paper. (*b*) The wiring for electric cranes generally supplies a negative wire with which contact is made by a trolley similar to that on the positive wire. In such cases it is preferable to use a double pole circuit-breaker *c*, shown in the figure, which should be inserted in the circuit directly after the wires leave the main switch *s* on the crane. (*c*) To detect a ground, connect two lamps *a* and *b* in series, each lamp being of the same voltage as the line. Connect a button *k* in circuit, as shown, one of its terminals being connected to the common connection between the lamps, and the other to the ground. Then if a ground exists on the wire, for instance, it will be evinced by the lamp *a* burning at full candlepower, while previously each was burning dimly. At the same time that the button is pressed (the negative wire being grounded), the lamp *b* will stop burning. (*d*) The solenoid should be wound with about 2,000 feet of No. 24 double cotton-covered wire.



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(513) Kindly explain the rule by which angles can be laid out with the aid of a 24″ × 18″ steel square that is graduated to inches, eighths, and sixteenths of an inch.

B. J. M., Pittsburg, Pa.

ANS.—The explanation of these rules, together with much additional information of equal value, will be found in a book entitled "Steel Squares and Their Uses," by Fred. T. Hodson, price $1.00, for sale by The Technical Supply Co., Scranton Pa.

***

(514) Please describe the hard and the soft soldering processes, giving the chemistry of the subject, the nature of the union between the surfaces joined, the action of the fluxes, etc.

G. H. B., New Plymouth.

ANS.—Hard soldering, or brazing, is a process of joining together two metals by means of a solder composed of brass, or by solder composed of brass and silver. The surfaces to be joined are thoroughly cleaned and wired together. A few pieces of hard solder are spread over the joint, which is then sprinkled with calcined borax. Heat is then applied until the solder melts and flows into the joint. The whole thing is then allowed to cool before being disturbed. Soft soldering is a process of joining together two metals by means of a solder composed chiefly of lead and tin. The surfaces are cleaned and sprinkled with a flux which varies with the kind of metal to be joined. Solder is then melted from a bar by means of a hot copper soldering bit, and is allowed to fall on the joint, or seam. The hot bit is then applied to the seam until the solder soaks into it. The union between the surfaces of the metals and solder is simply one of adhesion. In order that the surfaces may adhere they must be perfectly clean, and for this reason the calcined borax and other fluxes are used. These, when heated, flow over the surfaces of metals and solder, dissolving and carrying off any grease, oil, oxides, or other impurities which may be present.

***

(515) Please show how to find the number of real roots in the following equation:

$$4y^4 - 96y^3 + 828y^2 + 48y - 255 = 0.$$

How is the position of the decimal point determined in case the equation contains any roots less than unity? Give a complete solution of the equation $Bx^3 = A(D - x)^3$.

J. R., Baker City, Ore.

ANS.—The answer to this question would occupy more space than we can afford in these columns, and it would not be of sufficient general interest to warrant our publishing it. We recommend you to purchase Todhunter's "Theory of Equations," or Olney's "University Algebra." The latter is the easier to study. These books can be obtained from The Technical Supply Co., Scranton, Pa.

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(516) (*b*) What potential is required, as indicated by length of spark, to operate a Tesla coil satisfactorily?

L. E. B., Elmira, N. Y.

ANS.—(*b*) The potential required to send a spark through the air varies from 15,000 to 20,000 volts per inch length of spark. However, authorities differ greatly on this point. The condition of the atmosphere has to be taken into account.

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(517) Can you give me the composition of a solder suitable for aluminum?

E. E. O., Chicago, Ill.

ANS.—See HOME STUDY MAGAZINE, April, 1898, Answers to Inquiries, No. 137.

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(518) Some of the rings on the ends of the links of my 100-foot engineers' chain have parted. Can I rebraze them with an alcohol lamp and blowpipe? If not, tell me how I *can* do it; and what materials to use.

J. B. G., Fort Smith, Ark.

ANS.—You cannot get enough heat from an ordinary alcohol lamp and blowpipe unless you set the break over a piece of charcoal, and braze it there. Even then it will depend upon your skill in handling the flame. You can easily try it. If you fail, try a stronger flame—a gas-and-air flame, for instance—with a proper blowpipe.

***

(519) How can a blueprint be obtained from a blueprint?

W. C. K., Clinton, Iowa.

ANS.—Soak the print in a strong solution of ammonium carbonate until bleached out; then, after washing thoroughly, immerse it in a solution of tannic acid until the parts that were previously blue have become a deep-wine color. Wash the print again for half an hour in running water; then dry it and rub it over thoroughly with sweet oil until the paper is thoroughly permeated. When the oil is dry, the print may be put in the printing frame and a copy made of it in the usual manner. See HOME STUDY MAGAZINE, November, 1898, article entitled "The Duplication of Drawings."

***

(520) (*a*) What size and how much wire will be required for the secondary of an induction coil to get a spark ½ inch long? (*b*) Give dimensions of

primary coil for above. (*c*) How many open-circuit batteries are required? (*d*) Will a ¼-inch spark light an ordinary gas jet? (*e*) Will the spark pass through a series of breaks ¼ inch long?

A. E. F., Rightsville, Pa.

ANS.—(*a*) Make the core ½ inch in diameter, of No. 18 iron wire, and 5 inches long. For the secondary coil, wind 1 pound of No. 36 B. & S. double cotton-covered wire over the primary, following the instructions as to insulation given in HOME STUDY FOR ELECTRICAL WORKERS, Sept. and Oct., 1897, Answers to Inquiries, No. 49. (*b*) The primary coil should consist of two layers of No. 16 B. & S. single cotton-covered wire. (*c*) Use four bichromate cells. (*d*) Yes. (*e*) Yes, if the series of breaks has a total length of not more than ¼ inch, but not across more than one ¼-inch break.

* * *

(521) In HOME STUDY MAGAZINE, August, 1898, Answers to Inquiries, No. 304, you give the reading of the meter as 2,348,200. Kindly explain why the reading of dial *a* is 200. Should it not be 100?

S. H. P., Dorchester, Mass.

ANS.—The reading on dial *a*, to be as exact as possible, is approximately 170. This reading multiplied by 2 = 340 watts. The difference between this value and 400 watts being only 60 watts, represents a maximum value of 1.2 cents. By denoting the hundreds by the numeral nearest which the needle is, the matter is adjusted with equity.

* * *

(522) Can you give me any information as to the kind of ink used on typewriter ribbons? I find that, in the ribbons I use, the ink is exhausted long before the ribbons are worn out, and it has occurred to me to reink them and so save the cost of new ones.

SUBSCRIBER.

ANS.—Take the following ingredients in the proportions named:

Aniline black	½ oz.
Pure alcohol	15 oz.
Concentrated glycerine	15 oz.

Dissolve the aniline black in the alcohol, and then add the glycerine. Lay the ribbon on a flat surface, shake the ink and then apply with a brush (a tooth brush will do), rubbing the ink well into the fabric of the ribbon. If colored inks are required, get the suitable aniline colors.

* * *

(523) I want to build a 2-horsepower gasoline engine. Can you give directions or drawings, in HOME STUDY MAGAZINE, which will enable me to construct one? If not, can you tell me where I can get complete drawings for the purpose?

H. C. N., East Haven, Conn.

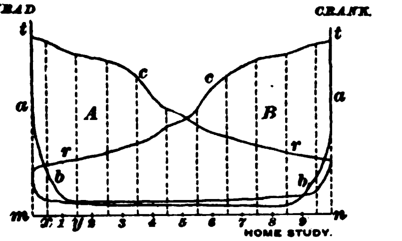
ANS.—The Mianus Electric Co., Mianus, Conn., will sell you a complete set of blueprints for a gasoline engine.

* * *

(524) Please explain enclosed indicator card, taken from a Buckeye engine: boiler pressure, 100 pounds gauge; piston diameter, 8¾ inches; piston stroke, 12 inches; revolutions per minute, 300; diameter of feedpipe, 3 inches; diameter of exhaust pipe, 4 inches; scale of spring, 60.

A. P. A., Fairmont, Minn.

ANS.—We have marked the principal points on the card as follows: *a* is the admission line, the verticality of which shows that the admission of steam is very prompt; *c* is the point of cut-off (looks about 30 per cent.); release is taking place in the neighborhood of *r*; *b* is the compression line; the sharp corner *t* shows a momentary rise and fall of pressure, due doubtless to the recoil of the spring, the engine speed being considerable; *t c* is the steam line, drooping a little owing to the high speed of engine. To find the horsepower of the engine from the above cards, proceed as follows: Mark off the length *m n* on the atmospheric line equal to the projected length of the diagrams; divide it into ten equal parts at the points *1, 2, 3, . . . 9*. Bisect each of these parts *m-1*, *1-2*, etc. at the points *x*, *y*, etc., and through these points draw lines perpendicular to *m n*, crossing the diagrams as shown. Measure the length of each line as intercepted by the boundary line of the diagrams, and add all these lengths together. Doing this, we find the total length of the ten lines to be 9.31 inches



for *A* and 9.62 inches for *B*. The scale of spring is 60; therefore, the mean effective pressure (M. E. P.) for *A* is $\frac{9.31 \times 60}{10} = 55.86$ pounds per square inch, and for *B* it is $\frac{9.62 \times 60}{10} = 57.72$ pounds per square inch. The M. E. P. for both cards is $\frac{55.86 + 57.72}{2} = 56.8$, say.

$$\text{Horsepower} = \frac{P \times L \times A \times N}{33{,}000},$$

where P = mean effective pressure (M. E. P.) in pounds per square inch;
L = length of stroke in feet;
A = area of piston in square inches;
N = number of strokes per minute = number of revolutions multipled by 2.

Substituting the proper values for the above, we have

$$\text{H. P.} = \frac{56.8 \times 1 \times 60.132 \times 300 \times 2}{33{,}000} = 62, \text{ about.}$$

Strictly, half the sectional area of the piston rod should be deducted from the area of piston (60.132) before inserting the formula. The cards are very full for such a high speed.

* * *

(525) (*a*) How many horsepower will it take to propel a flat-bottom boat that is 25 ft. long, 4 ft. wide, and carries 10 persons? Speed required, 5 miles per hour. (*b*) Which would you recommend, a steam engine, or a gas engine, for the above boat? (*c*) How is the indicated horsepower of a gasoline engine obtained?

W. B., Millington, Ill.

ANS.—(*a*) So much depends upon the lines of the boat that no accurate answer can be given. We should, however, recommend 2½ to 3 horsepower. (*b*) A gasoline engine, by all means, provided, however, that it is of standard grade. (*c*) See HOME STUDY MAGAZINE, July, 1898, article entitled "Gas Engine Testing."

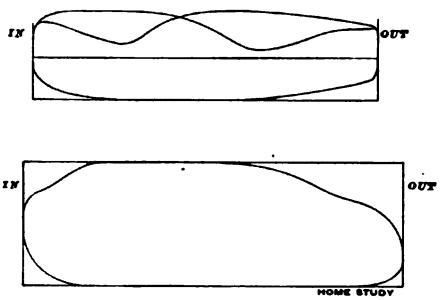
* * *

(526) Kindly explain the enclosed diagrams, noting in particular if the steam or the exhaust ports appear to be too small and giving cause of the drop in the steam line in the low-pressure cylinder cards. The engine is a fore-and-aft compound marine, having cylinders 10 inches and 22 inches in diameter; stroke, 12 inches; high-pressure crank 90 degrees in advance of low pressure; high-pressure cylinder has piston valve; low-pressure cylinder has ordinary slide valve; both valves are worked by link motion. At the time the cards were taken, the steam pressure was 135 pounds gauge; vacuum gauge, 24 inches; number of revolutions per minute, 140; scale of spring for high-pressure cylinder, 80; for low-pressure, 10.

A. M. H., Gig Harbor, Wis.

ANS.—It is difficult to say exactly what causes the drop, but it appears to be due to the closure of the

exhaust port on one end of the high-pressure cylinder before the release from the opposite end opens. The supply of steam to the low-pressure cylinder is thus partially interrupted during a part of the stroke, causing the pressure to fall, as shown by the cards.



When the release from the high pressure again opens, there is a new supply of steam, which restores the pressure during the latter part of the stroke of the low-pressure piston.

***

(527) Given two smokestacks identical in every particular; if one of them is painted black and the other white, will there be any difference in the drafts of the two? If so, why? CONSTANT READER.

ANS.—The color of the paint can have no appreciable effect on the draft.

***

(528) Kindly explain the process by which the antique green finish, commonly seen on bronze hard ware and ornamental brasswork, is obtained. I wish to get the same effect on a copper tile roof.

W. T. H., Brooklyn, N. Y.

ANS.—The finishing color of hardware, chandeliers, etc. is usually acquired by lacquering, but this method would not be desirable for a copper roof. We would suggest the coloring of the copper by oxidation as follows: In a gallon of water dissolve 1 pound of nitrate of iron and 1 pound hyposulphite of soda. In this solution immerse the well cleaned copper articles to be oxidized, and leave them until the desired color is attained, after which they should be washed in pure water, dried, and polished with a brush.

***

(529) Kindly give the formulas and explain the process of making sensitized dry plates and paper for photographic purposes.

G. H. W., Hokendauqua, Pa.

ANS.—This is a subject of too great extent to be answered in these columns. There are many different processes for making dry plates and photographic papers, and each process may be worked with many different formulas. We would advise you to read "The Textbook of Photography," by Capt. Abney, for sale by The Technical Supply Co., Scranton, Pa., price $1.50.

***

(530) What quantity of water will flow per minute through a 2-inch pipe, 40 feet long, under a pressure of 40 pounds per square inch?

G. A., Greenville, N. H.

ANS.—With a smooth and moderately straight pipe, the discharge will be about 300 gallons per minute. If the pipe is rusted or has short bends, the flow will be considerably less.

(531) What is the proper pressure to be maintained in the suction of a single-acting ammonia compressor for refrigerating work? The brine temperature is 18° F., and the pressure of ammonia in receiver tank is 175 pounds per square inch.

J. B., New York, N. Y.

ANS.—According to the tests of Mr. J. E. Denton, the proper suction pressure for ordinary conditions is 28 pounds per square inch above the atmosphere. See Trans. A. S. M. E., Vol. XII, or Kent's "Mechanical Engineers' Pocket Book," page 995.

***

(532) A triangle abc is right-angled at a; the base $ac = 60$, and $ab + bc = 120$. What is the length of the hypotenuse bc, and how is it figured?

H. L. P., Parkersburg, W. Va.

ANS.—Let x denote the length of the hypotenuse. Then we have,

$$\overline{bc}^2 = \overline{ab}^2 + \overline{ac}^2.$$

Or, $$x^2 = (120 - x)^2 + 60^2.$$

Solving, we get $x = 75$.

***

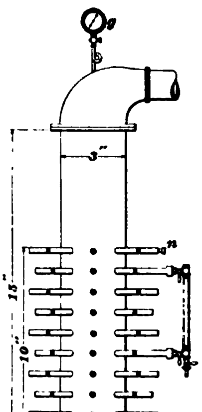
(533) I desire to use a dynamo for igniting the charge in gas and gasoline engines. (a) What kind of dynamo or generator would you recommend for the purpose? (b) Will it be necessary to use a spark coil? (c) Where can I purchase the machinery you recommend, or where can I obtain the information necessary for making them?

H. H. S., Hagerstown, Md.

ANS.—(a) You should employ a magneto-generator. (b) No; a spark coil is necessary only when using a current of low voltage. (c) Write to The Holtzer-Cabot Electric Co., Brookline, Mass., giving them full particulars.

***

(534) (a) Enclosed sketch represents a steam boiler intended for supplying small quantities of steam. Is such a boiler perfectly safe, working pressure being 120 pounds gauge? (b) If I send you a sample of oil that is said to be crude oil, will you examine it and analyze it for me? (c) Please describe the appearance of petroleum.



H. S. M., Lambertville, N. J.

ANS. — (a) Yes. (b) No; but we can recommend to you Messrs. Ricketts & Banks, analytical and consulting chemists, New York City. (c) Petroleum in its crude state varies in its appearance from that of a dirty kerosene to that of moderately thick molasses. It is usually of the consistency of ordinary paint, brown in color, frequently reflecting greenish light. It invariably has a greasy feel and a fatty appearance.

***

(535) Kindly give me the name of a good book on the smelting of copper and silver ores; also, price and where I can get it.

W. J. B., Barton Heights, Va.

ANS.—"Modern Copper Smelting," by Edward D. Peters, M. E., M. D.; price $5.00. For sale by The Technical Supply Co., Scranton, Pa.

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HOME STUDY MAGAZINE.

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IS THE WORLD GROWING SMALLER?

George F. Lord.

ANCIENT IDEAS—THE DEVELOPMENT OF RAPID TRANSIT—TO SAVE TIME IS TO LENGTHEN LIFE—THE TWENTIETH-CENTURY BUSINESS MAN.

HUNDREDS of years ago, the ideas entertained by the inhabitants of the world, concerning its size and shape, were extremely vague. The very few who gave the matter any serious thought imagined that they lived on a sort of flat disk, and that the known inhabited land was in or near the center, and surrounded by a circular rim of water, of greater or less extent. But, as years rolled on, and such men as Eratosthenes and Ptolemy began to investigate the subject of geography, many learned men began to suspect that the earth was round, and that it revolved on its axis. The voyages of such explorers as Marco Polo tended to confirm this theory, although for many years there existed a wrong idea concerning the extent and shape of the continents of Asia and Africa.

THE YANKEE PACKET SHIP "DREADNAUGHT."

Christopher Columbus was one of those who believed that the eastern shores of Asia extended far out into the Pacific; and, calculating on the new theory that the earth was round, he thought that by sailing west he could reach the shores of Asia or the East Indies.

After difficulties and discouragements that would have disheartened the majority of men, Columbus finally obtained financial support from Spain, and, after equipping three small vessels, started on his first voyage. There is no more striking example in history of a man's perfect confidence in his own convictions than this project of Columbus. It required a vast amount of courage to face the superstition and ignorance of the age, and steer boldly out upon an unknown sea, where every foot of progress took the voyager farther away from all that was known and tried, into a boundless region of speculation and doubt.

We all know the difficulties which beset Columbus, and the glorious result of his voyage. But he, to whom all the credit was due, died ignorant of the value or the extent of his discovery. He imagined that he had visited the East Indies, and was not far from the coast of China. We may observe here that this mistaken idea made the world seem smaller than it really was, since it took no account of America and the Pacific Ocean. But Columbus's discovery was the signal for various other expeditions from the different countries of Europe and Africa. One of these, commanded by Magellan, circled the globe, and thus established the first true idea of the size of the earth. This expedition occupied three years and twenty-seven days. Of course, much of that time was spent in exploring new coasts, but, making all allowances, a voyage around the world meant fully two years of danger and hardship.

From that time down to the present day, history records a succession of more or less successful attempts to lessen the time required for journeying from one point to another on the earth's surface. In the first place, sea voyages were greatly shortened by the rapid improvements in sailing vessels, the time required to sail from New York to Liverpool being gradually reduced until, in 1859, the famous Yankee packet ship "Dreadnaught" made the voyage in 13 days and 8 hours. But it was the invention of the steam engine, and the application of steam to ships and locomotives, that wrought the most wonderful changes in modes of travel. The speed of vessels has been steadily on the increase, until, at the present day, the "Campania" and other up-to-date ocean greyhounds cross the Atlantic in little more than 5 days. The average speed of the first railroad trains—such, for example, as the old "Spitfire" used to haul on the Delaware, Lackawanna & Western Railroad—was not more than 8 miles an hour. Today, a speed of 40 miles an hour is easily maintained, and some of our special trains—as the "Empire State Express"—average 50 miles, and, during bursts of speed, have been known to travel at the rate of 90 miles an hour.

THE CUNARD STEAMSHIP "CAMPANIA."

When Jules Verne wrote that very interesting book, "Around the World in Eighty Days," he was generally regarded as a very clever exaggerator of what was possible. But the globe has already been circled in much less than 80 days, and there is now every reason to believe that in the near future 40 days will be sufficient.

Washington required a week in which to travel from New York to Boston. In the same length of time, President Grant during his administration could have traveled from New York to San Francisco. Another striking example of this gain in time was shown during the recent "Klondike" excitement. At the time of the discovery of gold in California, the would-be miner was obliged to undertake either a long and perilous journey across the plains in wagons, or sail to San Francisco by way of Cape Horn; whereas the "Klondiker" of today boards a train in the East, and one week later arrives at the Pacific Coast.

Two centuries ago, when a man undertook a journey of, say, 300 miles, he made his will, bade farewell to all his friends, and started out with about as many chances of death as of safe return. The modern business man scarcely stops to say "good-bye" to his wife, but merely sends the office boy to her with the message, "Off for New York. Back tomorrow."

These illustrations go to prove that, for all practical purposes, the world is continually growing smaller. Modern progress steadily tends towards the annihilation of distance by improved methods of transportation. If a journey from New York to Chicago, that can now be accomplished in 24 hours, formerly occupied 30 days, then Chicago is certainly 30 times nearer than it used to be. Philadelphia is next door to New York, and London across the way

Another important effect of these changes is expressed in the adage "To save time is to lengthen life." Just think for a moment how seriously the progress of events would be impeded if we were obliged to return to the "stage-coach" methods of years ago, and do business without the telephone or the telegraph. We should feel as "slow" as does the man who is obliged to walk to his business while his bicycle is being repaired. All these devices for saving time have crept upon us so gradually that it would be almost

THE "SPITFIRE."

impossible to realize their value until we were deprived of them.

Life is made up of the sum total of all that a man sees and does and thinks about, and there can be no doubt that the man of today sees and does vastly more than his ancestor of a hundred years ago. And these changes in our environment are bringing about great changes in the character of the people. Through travel and mail and telegraph, we are constantly brought in touch with other places and other people. Our minds are broadening, and we are becoming "cosmopolitans"—citizens of the world. In years gone by, muscular strength and powers of endurance were absolute necessities in the make-up of the successful man, but nowadays we look for that mental alertness and decision of character which enable a man to perceive and take quick advantage of the opportunities presented to him. The normally constituted man of today can see more people, visit more places, and accomplish more work in 50 years than his great-grandfather could if the length of his life had been trebled.

The "Empire State Express."

The coming generations have much before them. There is no impossibility expressed in the belief that, inside of 50 years, the traveler may proceed over land at the rate of 100 miles per hour, and the time required to cross the Atlantic may be reduced to 3 or 4 days. Long-distance telephony will perhaps enable us to converse with our "English cousins," or sit at the desk in our office and "ring up" the Paris exchange. And finally, when every nook and corner of the globe has been visited and colonized, when the American flag has been tacked firmly to the end of the North Pole, and "Darkest Africa" has become popular as a health resort, we may expend our energies in "contracting" the universe, and bring Mars within signaling distance.

PRESSURE.

Benj F. La Rue

What Is Meant by Water Pressure and Steam Pressure.

The pressure of steam in a boiler or of water in a pipe is commonly spoken of as being a certain number of pounds. Thus, it may be said that *the pressure of steam usually carried in American locomotives is 160 pounds.* But, although such an expression as this conveys a definite meaning to those familiar with the subject, it is not very generally understood by others. The purpose of this article is to make clear the meaning of this and similar expressions.

The complete and definite statement regarding the pressure exerted by any fluid upon any body would give the number of pounds per unit of area; it is generally implied, however, when simply the number of pounds is stated, that the number represents pounds *per square inch.* For example: When referring to the pressure of steam, water, or any other fluid, as 80 pounds, what is meant is that a pressure of 80 pounds is exerted perpendicularly against every square inch of surface in contact with the fluid, regardless of the form or position of the surface.

The general law of fluid pressure, or hydrostatic pressure, was first discovered by Pascal; it is substantially as follows:

The pressure per unit of area upon any confined fluid is transmitted in all directions with the same intensity, and acts with the same force upon all contiguous surfaces, in a direction perpendicular to each surface.

Let Fig. 1 represent a vessel containing air or any other fluid, subjected to the pressure of the piston P, the weight of the fluid itself being neglected. Let it be assumed that the piston exerts a pressure of 80 pounds against the fluid, and that its area is 8 square inches.

The pressure upon the fluid will then be 10 pounds per square inch, for $\frac{80}{8} = 10$, and the fluid will exert a pressure of 10 pounds against every square inch of surface in contact with it. If it is assumed that the area of the small piston p is 1 square inch, then the pressure of the fluid against this piston will be exactly 10 pounds; so, also, at any point in the vessel, the pressure against the sides will be just 10 pounds per square inch. It will not matter whether the vessel be a steam boiler, the cylinder of an air compressor, or a water pipe—the general character of the pressure will be the same.

FIG. 1.

FIG. 2.

It will be noticed that a pressure of 10 pounds exerted by the small piston p will balance a pressure of 80 pounds exerted by the large piston P. This apparently phenomenal condition may be shown by the well known mechanical principle that *the power multiplied by the distance through which it moves must equal the load multiplied by the distance through which it moves.*

This principle may be illustrated by the lever shown in Fig. 2. A force p of 10 pounds exerted at the end of the 8-inch arm will just balance a force P of 80 pounds exerted at the end of the 1-inch arm, because, in order that there may be equilibrium, $P \times 1$ must equal $p \times 8$; hence, if $p = 10$, $p \times 8 = 10 \times 8 = 80 = P \times 1$, and therefore $P = 80$.

Now, suppose the longer end of the lever is rotated downwards 2 inches; as the amounts of movement of the two ends will be proportional to the distance from the fulcrum, the end of the short arm must move upwards one-eighth as far as the end of the long arm, which is $\frac{2}{8} = \frac{1}{4}$ inch. But it is evident that $10 \times 2 = 80 \times \frac{1}{4}$; in other words, the smaller force p multiplied by the distance through which it moves will equal the greater force P multiplied by the distance through which *it* moves.

This may be further illustrated by Fig. 3, in which p is a weight of 10 pounds attached to a rope wound upon a sheave 16 inches in diameter, and just balancing a weight P of 80 pounds attached to a rope wound upon the axle of the same, which is 2 inches in diameter. If the lighter weight p be lowered 8 inches, so that the point a will be at a', the greater weight P will be raised 1 inch, so that the point b will be at b'.

Exactly the same principle applies to the two pressures P and p in Fig. 1. As the area of the smaller piston p is 1 square inch, and the area of the larger piston P is 8 square inches, it follows that the smaller piston must move 8 inches, in order to displace $8 \times 1 = 8$ cubic inches of fluid, while the larger piston moves 1 inch in displacing the same amount of fluid, namely, $1 \times 8 = 8$ cubic inches. That is, the smaller piston must travel 8 times as far as the larger piston in order to displace the same amount of fluid, or, what is the same thing, in order to balance the larger piston. Hence, as the pressures of the two pistons balance each other, the pressure exerted by the smaller piston, multiplied by the distance through which it must move in order to displace a certain amount of fluid, must equal the pressure exerted by the larger piston, multiplied by the distance through which it must move in order to displace the same amount of fluid. If a pressure of 10 pounds be exerted by the smaller piston p, then $10 \times 8 = P \times 1$, from which $P = 80$ pounds.

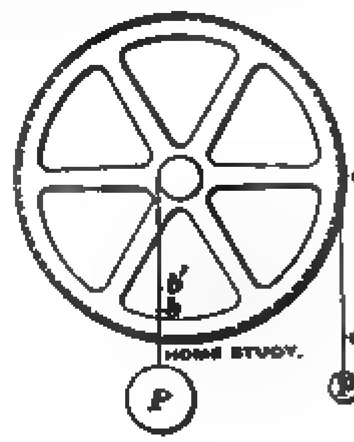


FIG. 3.

FIG. 4.

The area of the smaller piston p is 1 square inch, and its total pressure is 10 pounds; the intensity of its pressure is, therefore, 10 pounds per square inch. The area of the larger piston P is 8 square inches, and the intensity of its pressure is $\frac{80}{8} = 10$ pounds per square inch also. This will always be

the case, and is in accordance with Pascal's law stated above. It will be found that the pressure of the fluid against every square inch of surface with which it is in contact will be the same.

This principle holds true without regard to the form, size, or position of the vessel, if the weight of the fluid itself be neglected. If, in Fig. 4, the pressure of the piston P upon the fluid contained in the vessel a be 25 pounds per square inch, then 25 pounds will be the pressure of the fluid against every square inch of all portions of the sides and bottom of the vessel a. Likewise, if the pressure of the piston P upon the fluid contained in the vessel b be 25 pounds per square inch, then 25 pounds will be the pressure exerted by the fluid against all portions of the sides and bottom of the vessel b. If the pressure of the piston in a be 25 pounds per square inch, and the pressure per square inch of the piston in b be the same, then the pressure per square inch of the fluid in the vessel b will be the same as that in the vessel a. The *total* pressure of the fluid upon the bottom of the vessel b will not be the same as that upon the bottom of the vessel a, unless the areas of the bottoms of the two vessels are the same. If the area of the bottom of the vessel a is assumed to be 80 square inches, the total pressure upon the bottom will be $25 \times 80 = 2{,}000$ pounds. But, if the area of the bottom of the vessel b is assumed to be 12 square inches, the pressure per square inch being also 25 pounds, the total pressure upon the bottom of this vessel will be $25 \times 12 = 300$ pounds. Each vessel is said to be under a pressure of 25 pounds per square inch. The pressure upon the bottom of the vessel, due to the external pressure of piston, must not be confused with the pressure due to the weight of the fluid itself, or with the weight of the body of fluid.

In all the foregoing, the weight of the fluid has been neglected, as in the case of steam boilers, air compressors, etc.

THE GASOLINE ENGINE.

E. W. Roberts.

THE NATURE AND PECULIARITIES OF GASOLINE—PRINCIPLES OF CONSTRUCTION OF THE GASOLINE ENGINE—ITS ADVANTAGES AND SOME OF ITS USES.

GASOLINE—sometimes, but incorrectly, called naphtha—is one of the lighter products obtained during the distillation of crude petroleum. The nature of the substance is such that it slowly changes to a vapor, or gas, at ordinary temperatures, and if left in an open vessel soon entirely disappears by evaporation.

This property of rapid and spontaneous evaporation constitutes the chief danger in the use of gasoline, because the vapor readily takes fire, and, where the oil is partially or entirely enclosed in a vessel containing a sufficient quantity of air, a serious explosion is likely to follow ignition. On this account, a prejudice against the use of gasoline has arisen, which, however, a better knowledge of its properties, and of how to handle it, is gradually overcoming.

The gas engine, consuming ordinary illuminating gas, has for some years been quite generally used in cities where gas is not expensive. But in isolated places, or in the country, the inconvenience of the gas engine—not to mention the first cost of erecting a private gas plant—has rendered the employment of this source of power quite out of the question. For this purpose, and also as a portable motor, the gasoline engine is gradually filling a want formerly supplied only by the steam engine; and, in many small towns where illuminating gas is expensive, the comparatively low cost of gasoline has brought about its use, even where coal gas can be readily obtained.

In order that the reader may better understand the subject, the following short description of the general construction of a gasoline engine is given—taking, as an example, a very successful modern engine. The diagram shows merely the principles of construction.

Attached at a convenient point outside the building—usually to the wall if it is brick or stone—is the tank A, which is large enough to contain at least a barrel of gasoline, and is placed at a height above the level of the engine great enough to allow the gasoline to flow to the engine by gravity.

The gasoline is supplied to the engine by the pipe p, through which it flows to the regulating, or needle, valve F. The air entering the holes x passes over the hot cylinder head Y and beneath the brass cover Z, thence down the pipe G, from which, at each upward stroke of the piston E, and by way of the mixing valve B and pipe P, it enters the crank chamber C.

When E rises, the pressure of the atmosphere lifts the valve B, and allows a small quantity of gasoline to come in contact with the hot air rushing past from the pipe G. The gasoline is instantly vaporized and mixed very thoroughly with the air. As the piston E is driven down by the explosion of a similar charge, or supply, of mixed air and vapor, B closes automatically, the mixed air and vapor in C being compressed. When E nears the end of its stroke, that is, when it is nearly as far down as it will go, it passes the opening, or exhaust port, I, and the burned mixture is allowed to escape to the atmosphere. Soon after passing I it also passes the admission port, or opening, H on the opposite side of the cylinder, and allows the compressed mixture from C to flow into the cylinder O. This fresh vapor and air is deflected by the plate M to the top of O, whence it takes a downward path, as shown by the arrows, and drives nearly all of the burned mixture out through I. The piston E now returning, the ports H and I are closed and the contents of O are being compressed, while, below, more air and vapor is flowing into C.

When E is nearly at the top of the cylinder, an electric spark ignites the vapor, the mixture explodes, and E is driven down by the force of the sudden expansion of the gases. The entire operation is repeated at every revolution of the engine. A heavy flywheel, made fast to the shaft S, carries the engine round between explosions, and keeps the motion uniform.

Usually, two or three turns of the shaft, by means of a detachable crank, are sufficient to get the proper amount of gasoline and air into O. After the first explosion, the engine takes care of itself as long as it is properly oiled and the supply of gasoline holds out. The engine is stopped by closing valve F.

Because of the large amount of heat produced by the burning gasoline vapor, the cylinder O is usually surrounded by a jacket J, through which cold water is allowed to circulate from a service pipe, or is mechanically forced by means of a small pump on the engine. The ease of starting, the absence of dirt, the small amount of attention required while running, and, not the least important, the small expense for fuel, are all points in favor of this class of engine. Furthermore, an expert engineer's license is not required by the government, and this makes the gasoline engine a great boon to the owner of a yacht or launch; and thus, aside from the advantages mentioned above, any one may learn to operate a good class of gasoline engine in a few hours. The time required to get under way is usually less than thirty seconds; a few turns of the crank, and the engine is going, and taking care of itself.

Another good point in favor of gasoline engines is their simplicity. Although there are a few complicated engines on the market, the most successful have the fewest parts.

Engines for marine purposes are usually supplied with some form of reversing mechanism, apart from the engine itself—the change from forward to backward motion of the propeller being made without stopping the engine. Some makers reverse the engine

itself, but the former method is preferable, particularly with small engines, which do not reverse readily, and with all sizes of engines on crowded waterways.

As a source of power for horseless carriages, the gasoline engine continues to hold an important place. Of course, for cities and level roads, the electric motor is far superior, but on rough roads and in hilly districts the gasoline engine possesses advantages with which the electric motor cannot at present compete, the principal advantage being that a much greater amount of stored-up energy can be carried, and the supply can be more readily renewed. The principal objections to this use of gasoline, namely, odor and noise, have been almost entirely overcome by at least one firm of gasoline-carriage builders—their carriages traveling with less noise than a horse on an ordinary road, and giving off a scarcely perceptible odor.

Another class of motor to which gasoline has lately been applied is that of portable engines for farm purposes, and at least one firm in this country is now building traction engines driven by gasoline.

Even sawmill owners are taking up this form of motive power—this in spite of the fact that sawmills necessarily produce a great deal of waste suitable for fuel. They find that the gasoline engine practically saves the cost of an engineer; and, where gasoline is readily obtainable, it is continually finding favor.

No better example of the economy and convenience of the gasoline engine can be cited than that of driving dynamos for isolated electric lighting, since it brings into play the greatest skill of the expert designer and builder. To give good service on constant-potential circuits (those circuits on which the voltage or pressure remains always the same), the speed of the dynamo ought to vary but slightly from a fixed number of revolutions per minute.

In all early forms of gas engines, the speed was kept practically constant by cutting off the supply of gas entirely when the speed exceeded a certain rate—the engine missing explosions until the speed fell below the fixed rate, when the gas was turned on again.

Although for ordinary factory purposes this method answered very well, it was found that, on applying such engines to electric lighting, the fluctuation, or frequent change, in the rate of speed, was too great for good service, and various devices were tried in order to meet the difficulty. None, however, was so successful as that which depended upon controlling the force of the explosions, and allowing them to occur regularly. The best modern engine for this purpose is built with two cylinders, acting alternately on the same shaft, and giving two impulses at each revolution of the crank-shaft. The governor acts on a throttling, or choking, valve, usually placed in the pipe *P* (see diagram). Such engines run steadily, and with but little vibration, and give excellent results when used for electric lighting.

The field of the gasoline engine is large, and as its merits become better known, its more general adoption is but a matter of time.

EFFICIENCY.

C. P. Turner.

THE MEANING OF THE TERM—THE SIMPLEST MACHINES ARE THE MOST EFFICIENT—COMPLICATED MECHANISMS OFTEN RECEIVE UNDESERVED ADMIRATION.

WE often hear the word *efficiency* used in connection with machinery; for example, it is said that a Corliss engine has a high efficiency, while the efficiency of an undershot waterwheel is understood to be small. The makers of turbines state in their catalogues that their wheels have an efficiency of 60 per cent. if used under certain conditions, and 75 per cent. when the conditions are more favorable. All buyers and users of machinery have this term presented to them many times in the course of their work, and yet comparatively few really understand what efficiency is and how it is measured. Before we try to define the term *efficiency* as applied to machinery, let us stop to see what a machine really is and what its uses are. Most machinists and engineers have a pretty good idea as to how the particular machines they have been accustomed to build and use are made, and the kind of work they will do; a good many, however, have never stopped to consider all the relations that the machine bears to its work. They have thought of the machine almost as something having life and power in itself, instead of being merely an instrument through which outside forces were made to act.

FIG. 1.

A machine may be defined as any device by means of which the action of a force may be so directed that it can be made to do useful work. By useful work we mean the act of overcoming some resistance in order to change the form, the position, or the properties of some material in such a manner that it will better serve some particular purpose. For example, a mountain side is covered with a heavy growth of trees that we wish to convert into lumber suitable for building purposes. It is evident that a great deal of work must be done in order to cut all these tree trunks into boards, and to do this work we must have some source of power; in other words, we must be able to draw on some supply of energy. A stream flows down the side of the mountain; every pound of water in this stream that falls a vertical distance of 1 foot represents the expenditure of 1 foot-pound of energy. As the water rushes along, it strikes the rocks with a great deal of force, rolls the loose stones over and over one another, grinds the rocks into pebbles and the pebbles into powder, throws up spray and foam, and finally reaches the valley with all its energy expended, but without doing any useful work.

Now, we cannot apply the force of this falling water directly to the work of shaping the trunks of the surrounding trees into lumber; we can, however, direct the water so that it will exert its force on the vanes of a turbine and cause them to revolve; then, by means of gearing, shafting, belts, and pulleys, the force exerted by the falling water is transferred to the teeth of the saw, where it easily acts to cut the logs. The machinery of the mill is thus seen to be only a convenient combination of iron and steel, and wood and leather, by means of which we are enabled to so direct the force produced by the mountain stream as to make it do useful work.

Keeping in mind this idea of the relation which the machine bears to the power and work, let us take up the term *efficiency*, and study it by first noting carefully the

working of some of the most simple machines—devices that are so very simple and common that we hardly think of them as being machines at all. Right here let us say that it is by the study of these simple combinations—the ordinary appliances we see all around us—that we are finally enabled to understand the principles that govern the powerful engine driving the great mill or steamer, and the wonderful mechanism that does work which no human hand can duplicate.

A house is being built with high stone walls; the work to be done is to lift the stones from the ground to their place in the wall, and a horse furnishes the power. Now, a horse cannot be made to lift a load directly, so we make use of a simple machine—the combination of rope and pulleys shown in Fig. 1, where a horse is shown lifting a bale of hay into a barn. The arrangement is such that the distance traveled by the horse is equal to the distance the load is lifted. We will place a spring balance in the rope at a, so that it will measure the force required to lift the load, and another balance at b to measure the force with which the horse pulls on the rope.

FIG. 2.

Suppose, now, that the load to be lifted weighs 100 pounds, as shown by the balance a. When the horse pulls until the load begins to rise, we see, by watching the pointer on the balance b, that he pulls with a force of 125 pounds.

The height to which the load is lifted is 20 feet; consequently, the useful work that has been done, expressed in the common unit, is $100 \times 20 = 2,000$ foot-pounds. In lifting the load through this height of 20 feet, the horse has had to exert a pull on the rope of 125 pounds while traveling an equal distance; he has, therefore, imparted an amount of energy to the machine equal to $125 \times 20 = 2,500$ foot-pounds.

The difference between the useful work done and the energy expended represents the energy that has been required to overcome the resistances due to the motion of the rope and pulleys.

Now, let us compare the useful work done with the energy that was imparted to the machine. In order to do 2,000 foot-pounds of work, we had to expend 2,500 foot-pounds of energy; therefore, the work done by the expenditure of 1 foot-pound of energy was $2,000 \div 2,500 = .80$ foot-pound. The amount of useful work done may be expressed as a percentage of the energy expended; thus, in the present case, the useful work is 80 one-hundredths, or 80 per cent. of the energy. *This percentage, which represents the ratio of the useful work to the energy expended in doing it, is the efficiency of the machine*, and, as we have seen above, *the efficiency is found by dividing the useful work done by the energy expended in doing it.*

The work and energy may be expressed in any convenient unit, as foot-pounds, horse-

powers, heat units, or watts, but in all cases the same unit must be used for both.

Now, a horse can pull only a certain number of pounds, and it often happens, as in large building operations, that many of the stones to be used are so heavy that one horse cannot lift them by the device shown in Fig. 1. We might hitch enough horses to the rope to lift the stones direct, but this would be inconvenient, so we make use of the more complicated machine shown in Fig. 2, which enables us to multiply the force with which the horse pulls so as to obtain the desired pull on the rope. The horse pulls against the end of a long lever, commonly called a *sweep*, and the force he thus exerts is transmitted through the gearing and the drum to the rope. The pull on the rope is greater than the pull exerted by the horse; but the horse must travel a distance greater than that through which the stone is lifted.

We will use a spring balance at a to measure the pull required to lift the stone, another at b to measure the force of the pull on the rope, and a third at c to measure the force with which the horse pulls against the sweep.

Suppose, now, that we lift a stone weighing 600 pounds. Let us compare the useful work done when the stone is lifted 10 feet with the energy imparted to the machine; we will also note the relation between the work done and the energy imparted to the rope as shown by the balance b, and compare it with the case in which the horse lifts the stone by pulling on the rope direct. When the stone weighing 600 pounds is being lifted, we find that the balance b shows a pull of 750 pounds. This is the pull that would have to be exerted if we had several horses pulling on the rope direct; for example, if each horse pulled 125 pounds, six horses would be required to lift the stone. Considering the rope and pulleys as a separate machine which receives its energy from the drum, we find that, in order to lift a 600-pound stone 10 feet, that is, in order to do $600 \times 10 = 6{,}000$ foot-pounds of work, the machine must have $750 \times 10 = 7{,}500$ foot-pounds of energy imparted to it. According to the definition, the efficiency of the rope and pulleys is $6{,}000 \div 7{,}500 = .80$, or 80 per cent., which is the same as found in the first case.

In order to do this 6,000 foot-pounds of useful work and impart 7,500 foot-pounds of energy to the rope through the drum, the horse has had to exert a pull of 100 pounds while traveling a distance of 100 feet. He has, therefore, imparted $100 \times 100 = 10{,}000$ foot-pounds of energy to the machine, and the efficiency of the device which enables him to exert a pull of 750 pounds on the rope is $7{,}500 \div 10{,}000 = .75$, or 75 per cent.

The efficiency of the combination by which the horse is enabled to lift the 600-pound stone is the ratio of the total useful work done to the total energy expended, that is, to $6{,}000 \div 10{,}000 = .60$, or 60 per cent. Of each 100 foot-pounds of energy exerted by the horse, only 60 foot-pounds are utilized.

The efficiency of the combination can also be found if we know the efficiency of the different parts of which it is made up. Thus, the efficiency of the rope and pulleys was shown to be 75 per cent. and that of the windlass 80 per cent. By multiplying these two together we get $.75 \times .80 = .60$, or 60 per cent., the same result that was obtained when we divided the useful work done by the total energy imparted to it. In accordance with this result, we have the following principle: *The efficiency of any combination of machines is equal to the product of the efficiencies of its separate parts.*

No machine, however simple, ever gives out quite as much energy in the form of work as was imparted to it; from this we see that the efficiency of a machine must always be less than 1. Since the product obtained by multiplying any number by a factor which is less than 1 is always less than the number itself, it is plain that the efficiency of any combination of simple machines must be less than the efficiency of any of its parts. This shows that, the more simple a machine can be made that will properly direct a given force so as to do the required work, the greater will be the work that force can be made to do. We thus see that complicated mechanical devices, while they impress the untrained with a feeling of wonder and admiration, are often an indication of poor design and a lack of knowledge of the first principles of mechanics.

THE MARINER'S COMPASS.

Ernest K. Roden.

USED IN CHINA 4,000 YEARS AGO—SIR WILLIAM THOMPSON'S LATEST—A MAGNETIC NEEDLE SELDOM POINTS NORTH—VARIATION CHART—INCLINATION, DIP, MAGNETIC STORMS.

IT IS not known to whom the world is indebted for the discovery of the directing power of the magnet or for its practical application as an aid to the traveler. Of one thing, however, we are certain: The person who was first to so support a loadstone or magnet as to leave it free to move around a vertical axis, and then saw it turn in one particular direction when left to itself, and afterward found that, wherever carried or placed, this assumed direction of the suspended magnet remained unaltered, was the inventor of the compass. It is also certain that the compass is one of the greatest and most useful inventions ever made, not only because of its definiteness as a discovery, but because of its continual and unceasing utility to mankind.

It is generally believed that in China the compass was known, and used as a guide for traveling on land, at a very early period in the world's history. The first historical mention of this belief is made in Pere Duhalde's "Annals of China," in which there is a description of a battle between the Emperor Ho-Ang-Ti and one Tchi Yeou, on the plains of Tchou-Lou, wherein it is stated that, when the emperor's forces were menaced by thick fogs, which made it difficult to pursue the fleeing enemy, and the soldiers had lost the course of the wind, Ho-Ang-Ti made a car, which showed them the four cardinal points and thus enabled them to overtake Tchi Yeou, bind him prisoner, and put him to death. Ho-Ang-Ti was the third emperor of China, and, according to statistics, lived about 2,400, or, at the latest, 2,350, years before the Christian era.

FIG. 1.

The instrument which Ho-Ang-Ti is said to have used cannot possibly have been anything but a magnetic compass, as nothing else could have pointed out a direction as it is said to have done. It may, therefore, be accepted as fact that the compass was known and used in China upwards of 4,000 years ago. The ancient Greeks and Romans were well aware of the attracting power of native iron magnets, or lodestones; and there is abundant evidence of their knowledge of all ordinary magnetic phenomena. But the direct quality of the magnet, which constitutes the essence of the mariner's compass, was not known to them. In the writings of Homer, Theophrastus, Plato, Aristotle, Lucretius, and Pliny, no trace of any knowledge of this most marked property is found.

Dr. Gilbert, of Colchester, England, physician in ordinary to Queen Elizabeth, in his "De Magnet," published in 1600, stated that the compass was brought to Italy from China by Marco Polo, in the year 1295, or thereabouts. But there is evidence of its having been used in France about the year 1150, in Syria during the same period, and in Scandinavia previous to 1266. The Norwegian historian, Asa Frode, in an account of the discovery of Iceland, says that in the year 868, when Folke Wilgerdson, a renowned viking, was about to set sail on his voyage of discovery,

he took with him three ravens to serve as guides, because in those times seamen had no *leiderstein* in the northern countries. In Icelandic, *leid* means "leader," and *stein* "stone"; consequently, *leiderstein* signifies "leading stone," or "guiding stone."

In all probability, this account was written about the end of the eleventh century, Asa Frode being born in 1060. There is strong evidence, therefore, that the mariner's compass became known in Northern Europe between the years 868 and 1100. It did not become generally known throughout Europe, however, until during the thirteenth century.

A poem written by Guiot, and belonging to the Bibliotheque du Roi, at Paris, contains a curious and interesting description of the compass, and of its use by mariners. The following literal translation of this poem is taken from Barlow's "Treatise on Magnetism" in the "Encyclopedia Metropolitana:"

Fig. 2.

This same star does not move, and
They (the mariners) have an art which cannot deceive,
By the virtue of the magnet,
An ugly brownish stone,
To which iron adheres of its own accord,
Then they look for the right point,
And when they have touched a needle (on it)
And fixed it on a bit of straw
Lengthwise in the middle, without move,
And the straw keeps it above,
Then the point turns just
Against the star undoubtedly.
When the night is dark and gloomy
That you can see neither star nor moon,
Then they bring a light to the needle,
Can they not then assure themselves
Of the situation of the star towards the point?
By this the mariner is enabled
To keep the proper course:
This is an art which cannot deceive.

In this passage, the words "and the straw keeps it above" undoubtedly imply that the needle was floated in water by the straw.

The immense assistance which the compass was to navigation may be appreciated when we remember that before its introduction the sailors, having only the position of the sun and stars to guide them, were completely bewildered when these were hidden by fogs or clouds, and, as a consequence, scarcely ever ventured out of sight of land. Nowadays, the compass, in one form or another, is familiar to all; the special description of the mariner's compass may, therefore, be very brief. It consists of one or several magnetic needles attached to the under side of a circular card of some semitransparent substance, such as mica. The circular card is divided at its circumference into 360 degrees, and also into 32 divisions of 11¼ degrees each, called *points*, the latter being subdivided into *half points* and *quarter points*. The four principal points, called the *cardinal points*, are named after the principal horizon points—North, South, East, and West. This card is delicately balanced on a central pivot, around which it is free to move in a horizontal plane. It is generally enclosed in a small metallic bowl or box—see Fig. 3—which is so hung as to preserve its horizontal position, notwithstanding the rolling or pitching of the ship. This box, again, is placed in the top of a strong case called the binnacle, which is firmly secured to the deck of the ship; this is shown in Fig. 1.

In the early part of the present century, when ships and instruments for navigation were rapidly improving, the compass was still a rude instrument, and not up to the requirements of the seaman. To verify this statement, it may be mentioned that, when

in 1820 the British admiralty ordered all compasses belonging to the navy to be examined, half of them were declared useless.

In a compass intended for use on board ship, the great difficulty is that of overcoming the disturbances of the card caused by the motion of the vessel. In 1837, a committee was appointed in England to look into this matter, and, if possible, to find a remedy for "an evil so pregnant with mischief." This committee, while insisting on extreme lightness in the fittings of the card, made considerable addition to its weight by applying more needle power than would otherwise have been desirable, in order to secure steadiness. In the days of sailing vessels, this additional needle power was fairly successful in counteracting the disturbing effect of the ship's motion, but the subsequent adoption of the screw propeller, and the violent and continuous motion which resulted, made it of little or no use. This greater difficulty was, however, partly met by suspending the compass box, or bowl, by a spring or by India rubber, and this method was still further improved for use on small vessels, and wherever the motion is very severe, by the introduction of the "liquid compass"—that is, a compass in which the bowl is filled with alcohol instead of air. The first practical liquid compass was patented by a Mr. Crowe in 1813, and since then it has been gradually improved by other makers until now it is, when well made, a very efficient compass for all purposes. It is especially adapted to stand severe vibrations and the shock of heavy gun firing, and is therefore to be found on every man o' war.

Fig. 3.

By way of summarizing the qualifications of a good compass, we shall describe Sir William Thompson's compass, patented in 1876—the best compass in use at the present time. A thin aluminum ring (see Fig. 2) is connected by radial silk threads to an aluminum boss, which rests on an aluminum cup having a centerpiece of sapphire poised on an iridium point. Instead of a single needle, there are eight thin strips of steel fastened to the silk threads, as shown in the figure. The paper rim bearing the points is divided at intervals, so that the contractions and expansions due to change of temperature may not produce warping of the aluminum. The entire weight of the whole arrangement is as follows:

Aluminum rim	76.0 grains.
Eight needles	54.0 grains.
Aluminum nave	2.0 grains.
Aluminum and sapphire cap	2.5 grains.
Paper	28.0 grains.
Silk thread	8.0 grains.
Total	170.5 grains.

This weight, which is little more than ⅓ of an ounce, is but one-seventeenth of the weight of the ordinary 10-inch compass previously in common use on merchant steamers and large sailing ships. The bowl of this compass is saved from violent oscillation by having in the bottom a quantity of castor oil, and a simple device prevents the card from jumping off the pivot when heavy guns are fired—a matter of no small importance in a naval engagement. The binnacle, Fig. 1, has complete provision for stowing away the magnets, soft-iron bars, and spheres used to counteract the magnetism of the iron of the ship.

In the practical use of the compass, it is necessary to know and guard against certain disturbing influences which would otherwise deflect the needle from its true direction.

When the phenomenon of the pointing of the magnetized needle on the earth's surface was compared with the effect of one magnetized needle or steel bar on another magnetized needle or bar, the conviction gradually gained ground that the earth is, or has the properties of, a large magnet. These properties are, in the main, two in number: first, *attraction and repulsion*, or the property by which one magnet will attract and repel another, according to definite laws; second, *induction*, or the property by which a magnet can impart magnetism, and so convert into a magnet any piece of iron or steel, either by contact or by mere proximity. In dealing with the magnetism of iron ships, this property of induction, hitherto little thought of by seamen, becomes of great importance.

The earth's magnetic force, by inducing magnetism in the iron of a ship, is the source of all magnetic disturbances of the compass.

As to how the earth itself became magnetized, nothing is definitely known. Possibly, it was and is magnetized by induction from some far distant source. But magnetism may be induced by *electricity*. If an insulated wire be passed around a piece of iron, and the wire be caused to convey an electric current flowing from positive to negative, the iron will become magnetized and will have positive and negative powers.

If we consider the trade winds, which flow around the earth from east to west, as acting like an electric current, the earth would be magnetized with a negative pole to the North and a positive pole to the South. Whether it is thus magnetized or not, this idea will aid the memory to recollect the magnetic state of the earth. At the same time, the analogy indicates the manner in which magnetic forces may be generated by electricity, and suggests the possibility of compass disturbances due to the increasing use of electricity on board ships. Our present knowledge concerning the magnetic system of the earth has been obtained very slowly, and is the aggregate result of the labor of many able men. Owing to its practical value and scientific interest, the study of terrestrial magnetism has formed one of the most attractive and at the same time most difficult subjects for scientific investigation.

The effect of terrestrial magnetism on the compass is that only at a few places on the earth does the north end of the needle indicate the true or geographical north. At all other places, the needle makes an angle with the true meridian. This angle, or error, is called the *variation* of the compass, and is termed easterly or westerly according to the side of the meridian to which the north end of the needle points. The approximate direction of the meridian is easily seen in the northern hemisphere by the position of the pole star. It must therefore have been well known to the early navigators—that is, to those who noted with any degree of care the pointing of the needle—that its direction did not coincide with the direction of the meridian, or, in other words, that it did not in all places point to the north. This fact seems to have been brought more prominently into notice by Columbus. On his first voyage in 1492, when well over towards the West Indies, he found that the needle pointed to the westward of north. In the seas which up to that time Columbus had navigated, it had always pointed to the *eastward* of north. Probably, therefore, it was the change—and especially its going from east to west—rather than the existence of a variation which arrested the attention of this celebrated navigator. The first reliable determination of the variation in England was made in 1580, when the direction of the north end of the needle was discovered to be one point to the eastward of the meridian. Since that time, the variation has been observed with increasing frequency and accuracy.

One of the most noted students of terrestrial magnetism was the astronomer Halley, who, in a chart published in 1700, made the first attempt to give a comprehensive view of the direction of the compass needle in all parts of the world. This chart contained the results of a voyage made by Halley himself, and such other information as was at that time available. Similar charts, more complete and accurate, have since been published; one of the very latest is shown in Fig. 4. The lines of no variation in this chart are represented by heavy thick lines, westerly variation by continuous fine lines, and easterly variation by dotted lines.

One of these lines of no variation passes, at the present time, through North Carolina, Virginia, and the very extreme western part of Pennsylvania. On the eastern side of this line the variation is towards the west, increasing in amount with the distance from it. At New York the variation is about 7° west, and at Portland, Maine, it is about 14° west. On the other side of the line of no variation, the variation is toward the east, being about 5° east at Key West, and reaching on the Pacific coast 15° or 20° east, or almost NNE. Magnetic variation undergoes a progressive change in amount, and, after long periods, changes of direction, or secular changes, take place; in other words, the variation vibrates between certain limits.

As an illustration of secular magnetic change it may be noted that in 1657 the line of no variation passed through London, while in the year 1669 it passed through Paris. The variation at these places had previously been easterly; since that date it has been westerly, attaining its western maximum in 1816, when it was $24\frac{1}{2}°$. Since the latter date it has been decreasing at the rate of 7 minutes annually, and is now about 18° west. In the eastern states of this country, the north point of the needle is moving westward at the rate of about 1 degree in 12 years.

In addition to these progressive and secular changes, there is a diurnal or daily variation ; thus, in the northern hemisphere the needle moves through a small angle to the westward during the day and returns to the eastward during the night. In the southern hemisphere a similar change takes place, but in an opposite direction. These latter changes, however, are too small to be of any importance to the navigator.

But there is another deflection of the magnetic needle, called *inclination*, or *dip*. This was discovered in 1576 by Norman, an instrument maker of London, who found that a needle, however well balanced, would, after being magnetized, depart from the horizontal and with its north end point downward. This inclination of the needle is zero at the magnetic equator, and increases till, at positions called the *magnetic poles*—about 18 degrees from the geographical poles—the needle points vertically downwards. The dip, being to some extent a measure of the intensity of the earth's magnetism, as well as materially modifying the directive force of the needle, is a matter of importance to the mariner.

In connection with the practical use of the mariner's compass, a serious difficulty arises from the disturbing influences of the magnetism of the ship, which causes a deflection of the needle known as *deviation*. This is a matter of the gravest consequence, for the ship's magnetism often baffles the skill of man to control. The difficulty is, of course, greatest with iron vessels, where the deviation of the needle is frequently so great as to render the compass almost useless. Various means of neutralizing the effect of the ship's magnetism have been suggested. One of these is to place magnets or bars of soft iron in the immediate neighborhood of the binnacle, and in such positions as to cause a disturbance contrary to that caused by the iron of the ship, and thus to leave the needle comparatively free. This is found to answer well in ships plying between British and European or North American ports ; but where, as in the Australian passage, they change their latitude considerably, such an arrangement is found to be worse than useless, as the magnetism of the vessel changes with the magnetic latitude, and causes an ever-varying deviation of the needle. In such cases a standard, or pole, compass is used, which is placed in an elevated position and as far as possible from the iron of the ship, especially from vertical masses, such as iron masts and funnels. When it is mentioned that an error of one point in steering means an error of about one mile in five, the necessity for the various precautions taken by the mariner will at once be recognized.

Besides the disturbances already mentioned, there are at irregular intervals other mysterious movements of the magnetic needle called *perturbations*, or *magnetic storms*, which lead to a wide field of inquiry. These magnetic storms are more frequent and more pronounced at times of maximum sun spots; indeed, according to Loomis, a great magnetic storm is always the accompaniment of unusual disturbances on the sun's surface. Auroral

Fig. 4.

phenomena generally produce extraordinary perturbations in the oscillations of the magnetic needle. The greater the auroral display, the greater the magnetic perturbation. Not only is the needle subject to unusual displacement during an aurora, but its movements seem to be simultaneous with the pulsations and waving motions of the delicate auroral streamers in the sky.

During a voyage made by the writer in high northern latitudes, and while watching a brilliant auroral display, so frequent in those waters, he noticed that, when the aurora sent forth into the sky a coruscation, or streamer, the magnetic needle immediately responded to it by a vibration.

After all, when considering the association of the magnetic storms with the occurrence of the aurora borealis, and also with that of maximum number of sun spots, there seems to be ample reason to believe that the three classes of phenomena are intimately connected, and that they furnish a subject of cosmical research of perhaps as great interest as any which has hitherto occupied the attention of the scientific world.

LENGTHS OF ELLIPSES.

A. Langerfeld.

NOT OF SAME NATURE AS CIRCLES—RULES USUALLY GIVEN ARE NOT CORRECT—GENERALLY APPLICABLE FORMULA—VERY ACCURATE FORMULA—TABLE OF MULTIPLIERS.

THE length of an ellipse cannot be found as easily as the length of a circle, because the curvature of an ellipse depends on two unequal diameters, while the curvature of a circle depends on only one diameter.

In a circle, no matter how large or how small, the length of the diameter always bears the same relation to the length of the circumference. This relation is represented—almost exactly—by the well known ratio 1 : 3.1416. Now, in ellipses there is no constant ratio of

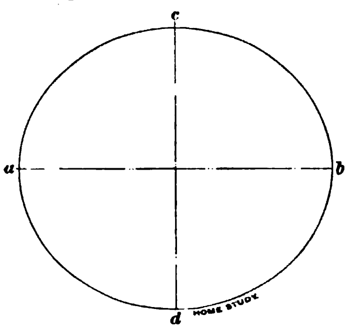


FIG. 1.

this kind, but, instead, an infinite variety of ratios, for the reason that the two principal diameters of an ellipse can bear an infinite variety of relations to each other; thus, in Fig. 1, $ab : cd :: 11 : 10$; in Fig. 2, $ab : cd :: 1\frac{1}{2} : 1$; in Fig. 3, $ab : cd :: 10 : 1$.

In many books it is stated that the length of the circumference of an ellipse is equal to 3.1416 times half the sum of the two diameters; or, what is the same thing, 1.5708 times the sum of the two diameters. The untruth of this will be readily seen by applying the rule to Fig. 3. The length of the circumference of this ellipse is evidently more than 1.5708 times $(ab + cd)$, because it is evidently more than twice ab. Taking ab equal to 1, then $cd = .1$, and $ab + cd = 1.1$. Then, $1.5708 \times 1.1 = 1.72788$, or nearly $1\frac{3}{4}$. As the circumference is evidently more than

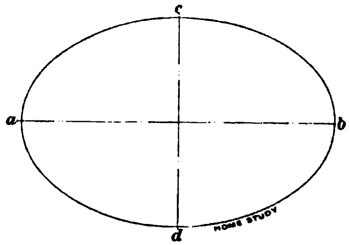


FIG. 2.

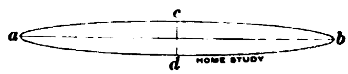


FIG. 3.

twice ab, this result is too small by more than $\frac{1}{4}$ of ab. If ab is 1 foot in length, the shortage will exceed 3 inches.

Applying the same rule to Fig. 2, the result is also much too short; and, even if applied to Fig. 1, the shortage will be considerable. If the diameters ab and cd are equal, the rule is right, but then the figure is no longer an ellipse, but a circle.

Many other approximate rules have been formulated, some of which are practically correct for ellipses of certain proportions, and more or less incorrect for others, while the rest are merely rough approximations, of doubtful utility.

The correct multipliers for finding the lengths of the circumferences of ellipses of the same shapes as Figs. 1, 2, and 3 (and also of a circle) are given in Table I.

TABLE I.

Ratios of Diameters.		Multipliers of the Sum of the Diameters.
Circle	1 : 1	1.5708
Fig. 1	11 : 10	1.5714
Fig. 2	3 : 2	1.587
Fig. 3	10 : 1	1.845

Thus, the correct length of the circumference of an ellipse, similar in shape to that shown in Fig. 2, and in which the lengths of $a\,b$ and $c\,d$ are, respectively, 12 inches and 8 inches, is $1.587 \times (12 + 8) = 31.74$ inches.

The differences in the above multipliers show that it is no simple matter to formulate a general rule for finding the lengths of ellipses.

For ellipses which commonly occur in metalwork, woodwork, and masonry, the following rule will give results practically correct:

Deduct the minor diameter from the major diameter and divide the remainder by the sum of both diameters. Square the quotient, divide the result by 4, and add 1. Then multiply by the sum of the two diameters, and by 1.571. The product thus obtained will be very closely equal to the length of the circumference, if the ellipse is not much narrower than Fig. 3, in proportion.

The above rule is expressed in a formula thus:

$$c = \frac{p}{2}(D + d)\left\{1 + \frac{1}{4}\left(\frac{D - d}{D + d}\right)^2\right\}$$

where c = length of circumference;
$p = 3.1416$;
D = length of major diameter;
d = length of minor diameter.

But the most convenient way to find the length of an ellipse of any proportion is to use a table of multipliers, such as given in Table II; this is to be used in the following manner: Find the ratio of the two principal diameters of the ellipse, then multiply the *major* diameter by the multiplier for the ratio corresponding most closely to the one in question. In case the ratio is between two of those in the table, take a multiplier similarly between the two nearest ratios.

TABLE II.
TABLE OF MULTIPLIERS FOR FINDING THE LENGTHS OF ELLIPSES.

Ratios of Diameters. Proportional.	Ratios of Diameters. In Decimals.	Multipliers for the Major Diameter.
1 : 1	1.000	3.1416
$1\frac{1}{10}$: 1	1.100	3.
$1\frac{1}{9}$: 1	1.111	2.986
$1\frac{1}{7}$: 1	1.143	2.95
$1\frac{1}{4}$: 1	1.250	2.838
$1\frac{1}{3}$: 1	1.333	2.764
$1\frac{3}{7}$: 1	1.429	2.692
$1\frac{1}{2}$: 1	1.500	2.645
$1\frac{3}{5}$: 1	1.600	2.59
$1\frac{2}{3}$: 1	1.667	2.557
2 : 1	2.000	2.424
$2\frac{1}{2}$: 1	2.500	2.303
$2\frac{2}{3}$: 1	2.667	2.273
3 : 1	3.000	2.226
$3\frac{1}{3}$: 1	3.333	2.192
4 : 1	4.000	2.142
5 : 1	5.000	2.094
8 : 1	8.000	2.042
10 : 1	10.000	2.03
1000 : 1	1000.000	2.

Taking the first example again, and applying the above rule and table, we first find the ratio of the diameters to be

$$20 : 8 = 2\tfrac{1}{2} : 1.$$

For this ratio the multiplier is 2.303; therefore, the length of the circumference is equal to $20 \times 2.303 = 46.06$ inches.

The following example illustrates how to find the multiplier, if the ratio of the diameters is between two of those in table: Let the given major diameter be 14 inches, and the minor one 10 inches. The ratio is $14 : 10 = 1.4 : 1$. As 1.400 is between 1.333 and 1.429 of the table, so is the correct multiplier between the multipliers 2.764 and 2.692.

To find this intermediate multiplier, deduct the ratio 1.333 from 1.429. The difference thus obtained is .096. The difference between the corresponding multipliers is

$$2.764 - 2.692 = 0.072.$$

The difference between the ratio 1.429, and our ratio of $1.4 = 1.429 - 1.4 = 0.029$. Then the amount x to be added to 2.692 to obtain the required multiplier, is obtained by simple proportion, thus:

$$.096 : .029 :: .072 : x;$$

whence, $x = .022$, and the required multiplier $= 2.692 + .022 = 2.714$.

A SIMPLE EXPOSUREMETER.

Louis Allen Osborne.

TIME AND INSTANTANEOUS EXPOSURES—THEIR RELATIVE VALUES—THE EXPOSUREMETER, OR PHOTOMETER, AND A SIMPLE WAY OF MAKING ONE—SPEED OF PLATES.

THERE is no problem in photography that presents to the tyro such a perplexing uncertainty as does the question of *exposure*. The purchaser of a camera receives therewith a book of instructions, describing minutely every detail—from the loading of the plate-holder to the adjustment of the swing-back—but on the subject of exposure the directions are painfully brief. The instructions accompanying the cheaper grades of cameras usually recommend "snap shots" in strongest sunshine only, while for cloudy days the "time" is stated to be from 5 to 15 seconds, and from 5 seconds to 2 minutes for interiors. Then, as though these vague statements were not sufficiently discouraging, the directions wind up by saying, "Nothing but long experience and many failures, accompanied by patience and perseverance, will enable the novice to correctly time his exposures." In consequence of this, snap-shot cameras and instantaneous exposures are made in every possible case, simply because the inexperienced "camerist" thinks time exposures more uncertain.

Now, let us consider this: If, with a given amount of light, an exposure of $\frac{1}{20}$ of a second on a fast plate is correct for a certain subject, then, in the same light, $\frac{1}{10}$ of a second would be an overexposure of 100 per cent., and $\frac{1}{40}$ of a second would be a corresponding underexposure. How are you going to distinguish between these extremely small intervals of time? Again, supposing the shutter were of a constant speed—say $\frac{1}{20}$ of a second—and everything was ready to "press the button" with the sun under a cloud, and just as the shutter snapped the sun came out full strength. Then the subject would receive twice the illumination expected, and the plate would be overexposed.

Now, suppose we go to the other extreme, and take a very slow plate—in fact, the very slowest, which requires about 20 times the exposure that should be given the fastest. The above subject and conditions would require on this plate an exposure of 1 second, which even a wild guesser at intervals of time could not overdo 100 per cent.; and, if the lens were well "stopped down"—say to $\frac{f}{32}$—making the proper exposure 8 seconds, an error of 10 per cent. would be almost impossible, and, even if it were made, would do no appreciable harm.

From this we see that time exposures give more latitude within the safe limit than does the snap shot, and at the same time are much more readily controlled.

If, then, we can ascertain, within 10 or 15 per cent., what should be the proper *time* for any given subject, we can start out on a kodaking trip in any kind of weather, with the assurance that our successful pictures will run pretty nearly 12 to the dozen exposures.

In these days of "you-press-the-button-and-we-do-the-rest" cameras, comparatively few of the alleged amateur photographers know anything about time exposures. Many owners of high-grade cameras seldom use a diaphragm smaller than will admit of a snap shot. Not one amateur in fifty appreciates the value of a real slow plate; and the use of color screens and isochromatic plates is considered by many to be confined to experts or cranks.

Now, if you were able to secure the exact exposure for any subject, on any plate, and in any kind of weather, would you experiment a little with the slow and isochromatic brands? If you would, you could learn something at every attempt you made, and if you wouldn't, it shows you are not destined to become a thoroughbred camera crank. It is quite generally known that it requires a shorter exposure for an open landscape than for one possessing considerable foreground, and that an outdoor portrait needs more time than the foreground of a landscape, all other conditions being the same.

This is all very good so far as it goes, but even if we know the ratio of exposures for these different subjects, it is of little value to us, unless we also know the exact exposure for at least one of them. The experienced

photographer exposes according to his judgment, the careless amateur makes a rough guess, the kodaker presses the button and trusts to providence, or luck, or some other uncertainty, and all three go into their several dark rooms expecting to get satisfactory results. The amateur and the kodaker (if he develops his own work) may endeavor to augment their chances of success, by developing their plates in a clothes closet, where there is no running water, and where the light is furnished by a candle in a cigar box, the front of which is covered by a piece of yellow post-office paper; while the hypo is conveniently placed in a soup plate on a soap box near by.

By a strange irony of fortune, such workers as these occasionally secure quite passable results, while the careful operator often fails in his undertaking. This, however, is no argument against careful work, and it is for the careful man only that the following remarks are intended.

A piece of Solio or Albuma paper will show a change of color, after an exposure of 5 seconds to the full sunlight, while an exposure of 20 to 60 seconds will render it a reddish-brown color. Now, if the strength of light that will turn Solio to a given shade in 5 seconds will properly impress a landscape on a fast plate in $\frac{1}{50}$ of a second, it stands to reason that an intensity of light that fails to turn the Solio to the given shade until 50 seconds exposure, will require $\frac{1}{5}$ of a second to impress the above landscape on the plate, all other conditions being the same.

Upon this principle are based a number of instruments with different names, but all intended to present to the photographer a royal road to correctness of exposure. The simplicity of the instruments not infrequently leads the user to become careless, and to blame his apparatus for his own blunders; but, carefully and judiciously used, an exposuremeter, or photometer, is a valuable instrument and a reliable instructor.

In Fig. 1 is shown a form of photometer, which can be easily made, is reliable to use, and costs next to nothing. It is intended to be pasted on the face of a watch, but can be printed on celluloid or on a piece of cardboard, if desired. The easiest way to make one would be to photograph Fig. 1 with an ordinary camera, thus reducing it to the size of the watch dial, and pasting a print of it on the crystal, as hereafter described.

First tack or pin this page against the wall, near a window, where it will be evenly illuminated by a strong north light; then place your camera on a table, in such a position that the center of the lens is on a line with the center of the dial in Fig. 1, making sure that the camera is level, as otherwise the resulting negative may show an elliptical dial instead of a circular one, which would not do at all. Focus to get the figures sharp, and then stop the lens down to $\frac{f}{64}$. Expose on a slow plate (Seed 23) for 30 seconds, or on a fast plate for 12 seconds; develop with a hydroquinone developer containing at least 3 grains of potassium bromide to each ounce. The resulting negative should come up slowly, and present perfectly transparent lines on a dead, opaque ground. Carry the development forward until the plate is nearly black; then wash, fix, and dry as usual.

Now make two prints from this negative, and after fixing them (they need not be

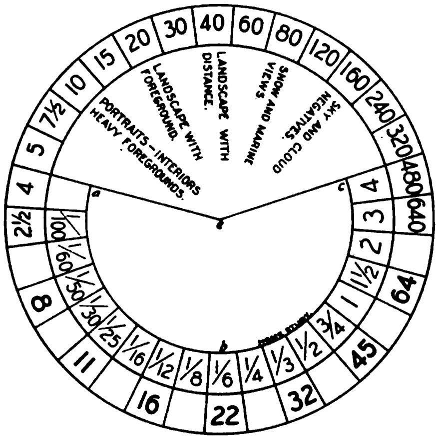


FIG. 1.

toned), carefully cut out the two dials with a sharp knife. On the larger, outside dial, the heavy figures from *8* to *64* correspond to the focal values marked on the lens stops, and the light figures from *2½* to *640* are the experimental exposure figures explained below. The figures on the inside disk are the exposures in seconds or minutes, according to circumstances.

Carefully cut the disks apart, and mount them upon the face of your watch as follows: Paste the outer ring on the dial of the watch so that the figure *40* of the exposure table is over the *XII* of the dial, and the number *22* of the top-scale is over the *VI* of the dial. Then cut the segment *a b c e* out of the smaller disk, and paste this disk to the inside of the crystal of the watch, so that the figures show through the glass, being careful to get

the point *e* exactly in the center, over the hand pinion, in order that, when the crystal is revolved in the basil, the radial lines of one circle will correspond to those of the other. If desirable, the dial, Fig. 1, can be cut out of the page and used, instead of photographically reproducing it.

Now, take a piece of yellow post-office paper or heavy Manila wrapping paper, and cut out a piece 1½ inches wide and 4 inches long, as shown at *a b c d* in Fig. 2. Just below the top—about ½ inch—cut a rectangular hole *e*, which shall be ⅛ inch wide by ⅜ inch long. Then fold the paper over on the

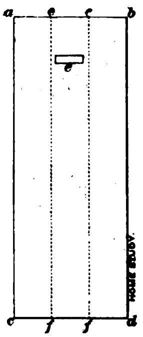


FIG. 2.

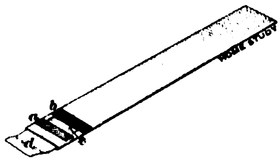


FIG. 3.

dotted lines *e f* and gum the wings, so that you have a long, narrow, flat tube or envelope, as shown in Fig. 3. On each side of the opening *e* is then pasted a piece of white paper tinted with water color or India ink, as described further on. One of these strips *b* is darker than the other *a*, in order to establish a reliable comparison.

Now, before using the instrument, a piece of Solio, Albuma, Aristo, or any other printing paper, is cut into strips ½ inch wide, one of which is inserted in the envelope, as shown at *d* in Fig. 3. When the instrument is to be used, and it is desired to determine the proper exposure for a given subject, you take out your watch, and pull the printing paper out a trifle, so that a fresh spot comes under the opening *e*, and note the number of minutes or seconds required to turn the paper a shade darker than the tint at *a*, but not so dark as the tint *b*. The watch crystal is now revolved in the basil so that the figure on the experimental exposure scale, corresponding to the number of minutes or seconds the paper was exposed, is opposite the general title of subject of which the photograph is to be taken—then, on the opposite side, under each size of stop, will be found the correct exposure for that stop in minutes or seconds.

For instance, suppose we are photographing an open landscape, with no foreground within a hundred feet; we find, on consulting our photometer, that it required 40 seconds to turn the silver paper to a shade between *a* and *b*. We then set the *40* of the upper scale opposite the subject *Landscape with distance*; and over *8*, on the lower scale of stops, we find the exposure would be $\frac{1}{50}$ of a second, or, with a small stop, we find under *64* the time required would be *1½* seconds. This would be with the fastest plates, while the slower ones would require proportionately longer exposures, according to the table given below.

Now, to determine the proper tints for *a* and *b*, it is necessary to work backwards, so to speak. Set up your camera on a dull or cloudy day, and focus on a fence or some foliage not more than 25 feet distant; close your shutter, put in $\frac{f}{64}$ stop, and, after placing your plate-holder in the camera, withdraw the slide 1 inch, and expose the plate for 1 second; close the shutter, and withdraw the slide another inch, and again expose for 1 second. Repeat this operation five times, and carefully develop the plate. Select, from the five 1-inch strips, the one that is the best quality of negative, and use the time of its exposure as the key to the situation. Suppose the strip that received 2 seconds' exposure were to be the best of the five. Turn the *2* of the exposure scale to the *64* of the stop-dial, and on the outside scale opposite *Landscape with foreground* will be found 30 seconds as the time required to turn the paper the desired color. Expose a piece of the paper you are to use, for 30 seconds to the same light which fell upon the object you were photographing, and then, in a subdued

1	1¼	2½	4	20
Cramer Crown. Hammer Fastest. Seed 27. Eastman's Film. Instantaneous Isochromatic.	Cramer Banner. Seed 26. Carbutt Eclipse. Record.	Seed 23. Cramer Medium. Isochromatic.	Cramer Anchor. Hammer Slowest. Carbutt Ortho 23.	Carbutt B 16.

light, tint *b* a little darker and *a* a little lighter than the shade to which your paper has turned. The closer these two tints approach the color of your paper, the more accurate will be your instrument.

In photographing through a color screen, it is simply necessary to use the screen with the photometer in estimating the exposure, in order to determine how much time is required to offset the color of the light. With orthochromatic and isochromatic plates this is not so important, but it gives a basis to work on in any case.

If it is not desirable to use the photometer as an appendage to your watch, a very neat instrument can be made by printing the two dials on Seeds positive films, and fastening them together with an eyelet at the center. In this case, the outer circle can be printed on a square piece of film, on the front of which the smaller disk is fixed to revolve, while on the back can be copied the table from the preceding page, which shows the relative speeds of different brands of plates.

In using any of the plates given in the table, multiply the time, as found on the photometer, by the number at the head of the column in which the brand of plates is named.

A WORD TO THE WISE,

OR

"BILLY'S SUGGESTION."

ONCE upon a time, as the story books say, a man who had the reputation of being "foolish" was engaged as helper in an English machine shop. Everybody knew he was foolish, for it was written all over his face. His mouth was always open, he never *thought* of such a thing as breathing through his nose, and his eyes looked everywhere and nowhere. He talked with a "thlight lithp," leaned forward as he walked, grinned when spoken to, and went about his work with as much apparent intelligence as a somnambulist. They called him "Billy."

When he had nothing particular to do himself, Billy had a habit of staring vacantly at others; in fact, he was always present where work was being done, and at all shop conferences he seemed to resolve himself into a silent investigation committee. Whether or not he added to his slender stock of knowledge, at these conferences, or mentally criticized what the "wise men" said, will never be known, but something that occurred at one of them is our present excuse for writing about him.

There had just been brought into the shop a new belt pulley, bored and key-seated, ready to slip on the end of the shaft. The pulley was lifted up and an attempt made to put it on the shaft, when it was discovered that the bore was too small—that the pulley would not go on. By this time, of course, Billy was around, all eyes and mouth, gazing at the pulley as if he thought it was alive, and was expecting it to get up and walk out of the shop.

The two men who were handling the pulley were nonplused. They put it down, and sending Billy to bring the foreman, stood waiting. The foreman and Billy soon returned. The men, after explaining the trouble, were told to try it again. They did so, but it was of no use. The bore was evidently too small.

"Did you send them a gauge to bore it by?" asked the foreman.

"Yes, sir," said one of the men, "and I'm quite sure the gauge was right."

"Well," said the foreman, "I don't know *what* to think of it. Billy, go find the superintendent, and ask him if he can come around for a minute or two."

In due time the superintendent appeared, and for his special benefit they tried the pulley once more. Then, as they put it down for the third time, the Boss happened along—wanted to know what the trouble was—had the matter explained—and then, along with the foreman, superintendent, and others who had gathered around during the conference, looked very serious. It was at this moment, when all was still and silent, that Billy, who had been staring about, looking more bewildered than usual, drawled out these remarkable words:

"Doant ye think it maat goo on, if ye wuth to turn it tother way raound?"

For a moment the "wise men" were too astonished to utter a sound. Then the Boss laughed; then they all laughed; then they "roared," because it was such a capital joke. But Billy didn't say a word. He just waited; and in a little while he got his reward. At a sign from the Boss, his suggestion was tried; then they all stopped laughing, for, sure enough, when the pulley was reversed, it went on all right.

PAPER MAKING.

Warren P. Smiley.

WHAT PAPER IS COMPOSED OF, AND HOW IT IS MADE—SOMETHING OF ITS HISTORY. THE SODA PROCESS—LOADING, SIZING, BLEACHING, AND COLORING.

DID IT occur to you when reading the above title that you were at that moment holding in your hands, looking at with your eyes, nay, even touching with the sensitive tips of your fingers, an excellent sample of the very material which the writer has chosen as the subject of an article? Probably not. Indeed, it would have been remarkable if it had, for you are naturally so familiar with the general appearance of the finished article, and so accustomed to reading what is printed upon it—without regard to the material itself—that the mere holding of a quarter of a pound or so of it in your hands has become a trifle of absolutely no significance. For all that, however, paper is an exceedingly interesting material, and, as we shall see, of great importance industrially.

As every one knows, certain spans of time in the world's history are known as the *stone* age, the *bronze* age, and the *iron* age, the reason being that these materials were the principal ones employed in the manufacture of the various tools and implements that were used during those times. The present age may possibly be referred to by posterity as the *paper* age—so numerous and varied are the purposes to which paper is now applied in the industrial world. And yet, comparatively few people know what paper is, or how it is made.

Paper is a thin felt of interwoven fibers, which have first been finely divided, then mixed into a pulp, and finally rolled into thin sheets and dried. The earliest form of paper used for writing purposes was probably the papyrus of the Egyptians; this was used at least 4,000 years ago. The Chinese made paper from artificially prepared pulp as early as the beginning of the Christian era. It is thought that in its manufacture they used cotton, the bark of trees, and similar materials. The Arabians learned the art from the Chinese, and about 12 centuries ago built a paper factory. It is believed that the manufacture of paper was introduced into Spain by the Moors, and from there spread to the rest of Europe.

As we have said, paper is a thin felt of interwoven fibers. Many fibrous substances, both vegetable and animal, have, at different times and places, been employed in its manufacture; but animal fibers do not make a good grade of paper, as bleaching agents do not readily act on them; they are also difficult to prepare in other respects. Cotton was one of the first substances used in paper making, and it is fitted for this purpose by the ease with which the fibers can be prepared. The paper made from cotton, however, is rather loose and spongy in texture, unless it contains some linen.

At a very early date, cloth, which is largely composed of interwoven fibers, was used, and for a long time rags formed the principal raw material in the manufacture of paper. Rags from hemp, flax, and cotton are still employed, but woolen and silk rags can only be used in making a cheap grade of paper, as the bleaching agents do not act on the animal fibers. In the manufacture of the finest grade of writing paper, linen rags play a very important part, but during the past half century, the quantity of paper manufactured has so largely increased that the supply of rags obtainable does not nearly meet the demand; for this reason, various fibrous substances have been introduced to take the place of rags. Among these are esparto grass, jute, straw, corn stalks, and wood.

In choosing a material from which to make paper, several things must be considered. The substance should contain a large percentage of fibrous matter, and should be easily freed from other materials; the fibers should be strong, and should knit well, forming a close, compact felt. Straw, when treated to free it from silica, yields a fiber which makes an excellent paper, but the loss of material and chemicals is so great that it has never been very largely used. The root cuttings of jute, and the waste from rope making, are rich in fibrous matter, but the paper made from them is of an inferior quality.

In 1840, F. G. Keller obtained a pulp from wood, by grinding it under millstones, but pulp thus prepared has the fibers so ground

up that it does not felt well; however, it can be, and is, used, as a "filling," with other substances, and also for the manufacture of an inferior grade of paper. Paper made from this *mechanical* wood pulp, as it is called, is easily torn, the fibers being too short to form a strong felt. Another objection to the pulp thus prepared is the fact that the resin, which remains in the pulp, resists the action of even a strong bleach, and paper containing this pulp soon turns yellow.

These objections are overcome by the introduction of what is known as *chemical* wood pulp—that is, wood pulp which is prepared by means of chemicals. The chemicals dissolve the resinous and other materials, and thus remove them from the wood fiber, or cellulose, and leave the fibers their original length, so that they interlace well, forming a strong paper of superior quality. In this country, at the present time, wood has almost entirely replaced the other materials used in paper making, and since its introduction the price of paper has fallen more than 50 per cent.

The accompanying table, taken from Wagner's "Chemical Technology," gives the percentage composition of some of the varieties of wood used in paper making.

Wood.	Water.	Watery Extract.	Resin.	Cellulose.	Incrusting Matter.
Birch	12.48	2.65	1.14	55.52	28.21
Beech	12.57	2.41	0.41	45.47	39.14
Oak	13.12	12.20	0.91	39.47	34.30
Alder	10.70	2.48	0.87	54.62	31.33
Lime	10.10	3.56	3.93	53.09	29.32
Chestnut	12.03	5.41	1.10	52.64	28.82
Fir	12.87	4.05	1.63	53.27	28.18
Poplar	12.10	2.88	1.87	62.77	20.88
Pine	13.87	1.26	0.97	56.99	26.91
Willow	11.66	2.65	1.23	55.72	28.74

From this table it will be seen that nearly all varieties of wood are rich in woody fiber, or cellulose. By the modern methods of treatment, this fiber is quite easily freed from the other constituents of the wood. In the United States, maple and basswood are largely used. The trees are freed from bark and branches, cut into logs and pieces of suitable size for handling, and run under a heavy knife, which cuts them across the grain into chips about $\frac{3}{4}$ inch long. These chips are placed in upright cylindrical tanks, about 7 feet in diameter by 27 feet deep, known as *digesters*, and treated with a sodium hydrate (caustic soda) solution, under a steam pressure of about 110 pounds per square inch. It requires about 2 hours to get up to full pressure, after which the stock is heated for $5\frac{1}{2}$ hours. The caustic-soda solution, which is added to the chips, is made by mixing calcium oxide (quicklime) with sodium carbonate, in solution. When the calcium oxide comes in contact with water, it forms calcium hydrate (caustic lime), thus:

$$\underset{\text{calcium oxide}}{CaO} + \underset{\text{water}}{H_2O} = \underset{\text{calcium hydrate}}{Ca(OH)_2}$$

The calcium hydrate thus formed, acting on the sodium carbonate, forms calcium carbonate and sodium hydrate, thus:

$$\underset{\text{calcium hydrate}}{Ca(OH)_2} + \underset{\text{sodium carbonate}}{Na_2CO_3} = \underset{\text{calcium carbonate}}{CaCO_3} + \underset{\text{sodium hydrate}}{2NaOH}$$

The calcium carbonate settles out in the form of a white precipitate, leaving the sodium hydrate in the form of a clear solution.

After being treated for about $5\frac{1}{2}$ hours at full pressure in the digesters, the resin, incrusting matter, etc. will be dissolved by the sodium hydrate. By means of the steam pressure, the stock is then forced up through a pipe to a large tank at the top of the building. From there it is discharged into the *wash pans*, which are upright, cylindrical tanks similar to the digesters, but having false, perforated bottoms. In these the stock is washed, first with weak liquor and then with hot water, until the last traces of alkali are removed. The washings are pumped into large pans, in which they are evaporated to a concentrate solution, and then to dryness in a rotary furnace, when the sodium is obtained in the form of carbonate, which may be rendered caustic by means of lime, and used again. In this way, from 50 to 90 per cent. of the soda is recovered.

After all the impurity has thus been removed, the pulp is washed through a screen, which holds back any chips that have not been acted upon by the caustic solution, and

from here it passes to the bleachers, where it is treated with a solution of bleaching powder (calcium hypochlorite) until thoroughly bleached. The precise action of this solution is not known. It is usually thought that bleaching powder is a mere carrier of chlorine, which it readily gives up, and that the chlorine thus set free acts as the bleaching agent, by breaking up the organic coloring matter. But it has been suggested that bleaching powder acts as an oxidizing agent, breaking up according to the following equation :

$$CaOCl_2 = CaCl_2 + O$$

and that the oxygen thus set free accomplishes the bleaching. It is possible that both of these actions take place.

Again, it is generally thought that the chlorine set free bleaches organic substances by uniting with the hydrogen of these compounds, thus breaking them up; but it has been suggested that the chlorine may unite with the hydrogen of the water present, setting oxygen free, which does the bleaching. It is sufficient for our purpose, however, that bleaching is accomplished, without going further into the process.

The cellulose has now been freed from other material and bleached, but it is not yet in a proper condition to make an even paper, as the fibers are not thoroughly separated from one another. To accomplish this separation, the bleached stock is next passed to the *beaters*, which are made in various forms, but all accomplish the same purpose, namely, the separation of the fibers. This is done by means of revolving blades, so arranged as to separate the fibers without cutting or breaking them, as long fibers felt much better and form a stronger paper than short ones. While in the beater, the pulp is usually loaded, sized, and colored.

To all papers, except the very finest, some inexpensive mineral matter, known as *loading* material, is added. This serves two purposes: It makes the paper cheaper, and fills the pores, so that the paper takes a better surface when finished. The minerals most commonly used for this purpose are kaolin, calcium sulphate, barium sulphate, chalk, bauxite, and agalite ; and the amount added varies from 2 to 20 per cent. of the weight of the pulp, depending upon the kind of paper. With the exception of blotting paper, all papers are also *sized ;* and the *size* is usually added at this point, although in some cases it is added later in the process, as the pulp is passing through the paper machine. When the sizing is done in the beater, resin soap is generally added first, then some starch—or the soap and starch may be added together—and, after they are thoroughly mixed with the pulp, a solution of alum is poured in. The sizing renders the paper capable of resisting, to a certain extent, the action of water. Thus, in writing and printing papers, the size prevents the ink from spreading as it does in unsized, or blotting, paper. When the sizing material is not added in the beater, what is known as *tub-sizing* is resorted to. In this case the paper, in going through the machine, passes through a tub containing a solution of gelatine, to which has been added about 20 per cent. of its weight of alum. In passing through, the paper takes a coat of this solution on both sides.

Bleaching never renders wood pulp perfectly white, but always leaves it with a yellow tint, which, if white paper is desired, must be neutralized by the addition of small quantities of blue and pink coloring matters. These are added in the beater. For the blue color, ultramarine, smalt, or aniline blue is used; and cochineal, aniline red, or brazil wood is used for the pink. If paper of any particular color is desired, the proper dye or pigment to produce that color is added at this point.

The various mechanical appliances by which the pulp is transferred to the rolls are too numerous and complicated to be described in an article of this character. Suffice it to say that, as a rule, the pulp is poured upon an endless wire cloth, which carries the pulp to the rolls. The first rolls through which it passes are covered with felt; from these it passes between a series of smooth, metal rolls, which gradually compress the pulp to the required thickness and make of the loose fibers a strong, firm felt. The rolls are heated, and by the time the paper is delivered from the last pair it is dry. At the end of the machine a knife cuts the paper into large sheets, which are then taken to the finishing room, cut to any required size, counted, and boxed for shipment.

A more recent method of preparing chemical wood pulp is known as the *sulphite* process. It is claimed for it that a larger yield of cellulose is obtained, that the pulp is of better quality, and that there is a greater economy of chemicals than in the "soda process" just described.

This process will be made the subject of a separate article in an early number of this magazine.

CALCULATING π WITHOUT MATHEMATICS.

George McC. Robson, M. A.

DISCOVERY OF AMERICA—DICE—LIFE INSURANCE.

"Old Archimedes, reverend sage!
By trump of fame renowned, Sir,
Deep problems solved in every page,
And the sphere's curved surface found, Sir:
Himself he would have far outshone,
And squared the circle too, Sir,
Had he our modern secret known,
And tossed a stick all day, Sir."
—*Astronomer's drinking song.*

Modern mathematicians, since the middle of the eighteenth century, employ the Greek letter π (pronounced *pi*) to represent the exact value of a very important incommensurable number. Since this number is incommensurable, its exact value cannot be expressed by any finite combination of figures; but its approximate value, to four places of decimals, is 3.1416.

The number represented by π is usually defined as the *ratio of a circumference to its diameter;* but it is possible that, if Christopher Columbus had lived at an earlier period, this number would have been differently defined. In ancient Egypt, before the discovery of America, real estate was scarce and therefore very valuable, whereas human life was superabundant and lightly esteemed; hence the real-estate man was a very important personage, and life insurance was unknown. Accordingly, the real-estate man commanded the services of the brightest intellects, and mathematicians developed the science of geometry that it might be used in the measurement of land. Thus, the Egyptian, and afterwards the Greek, mathematicians first encountered the number now denoted by π, in connection with the geometry of the circle.

It is evident, however, that a number may present itself in a great many relations; thus, five is the number of fingers on a man's hand, five is the number of cents in a nickel, five is the number of points on one of the stars in Old Glory. In the same way, the number π is a great many things besides the ratio of a circumference to its diameter.

Had life insurance, instead of real estate, been the controlling interest in those far-off days in Egypt, instead of calculating the length of fence required for a field of known diameter, mathematicians might have been engaged on such problems as the following: Of a large number of persons now alive, what is the chance that the number of survivors at a certain future time will lie between two given numbers? This is a very important practical question; and, if a mathematician ignorant of the geometry of the circle could solve it correctly, he would encounter the number now denoted by π, and would have to define it in some way and adopt some symbol to represent it.

Whatever department of mathematics we study, the number π will present itself at a very early stage of our progress; and this is not surprising, for π is simply four times the infinite series $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots$, and it is natural that so simple a series should be of frequent occurrence. For example, in studying the law of fluctuation from the average we find π. Thus, if the number π were unknown, the solution of the following problem would lead to its discovery: In six million throws of a die, what is the chance of the number of aces lying between one million $+ x$ and one million $- x$?

We shall find an easy and interesting, if not very reliable, way of calculating an approximate value of π in the solution of the following problem, which was proposed by Buffon, and solved independently by him and by Laplace: A floor is ruled with equidistant parallel lines; a rod shorter than the distance between each pair of parallel lines is thrown on the floor; what is the chance of the rod falling on one of the lines? It is easy to show, as Buffon and Laplace did, that in a large number of throws the number of intersections is to the whole number of throws as twice the length of the rod is to π times the distance between each pair of the parallel lines. Any reader who desires to know how this result is obtained will find

the solution on page 365 of Williamson's "Integral Calculus." In 1855, Mr. Ambrose Smith, of Aberdeen, Scotland, made three thousand two hundred and four throws with a rod whose length was three-fifths of the distance between each pair of parallel lines. He obtained one thousand two hundred and thirteen clear intersections, and eleven cases in which it was hard to decide whether the rod crossed a line or not. Now, it is a well established principle of criminal law that the prisoner is entitled to the benefit of the doubt; accordingly, we take advantage of the doubtful cases, and consider these eleven as intersections, giving altogether twelve hundred and twenty-four intersections. Therefore, by the solution of Buffon's problem given above, we have

$$\frac{1,224}{3,204} = \frac{6}{5\pi};$$

hence, $$\pi = 3.1412.$$

The error here is less than four ten-thousandths, and is remarkably small, considering the comparatively small number of throws made. It is to be remembered that, to obtain the approximation 3.1416 geometrically, mathematicians employ regular polygons of five hundred and twelve sides. Using polygons of over one million sides, Romanus, of Holland, about the beginning of the seventeenth century, computed π to sixteen places of decimals. With the easier methods of modern mathematics, Mr. Shanks has carried the calculation to over seven hundred places, which is far beyond the requirements of mathematics. Ten places are sufficient to give the circumference of the earth to the fraction of an inch, and thirty places would give the circumference of the visible universe to a quantity imperceptible with a microscope.

The determination of the exact value of π is commonly known as the problem of the *squaring of the circle*, or the *rectification of the circle*, because it is identical with the problem of constructing a square equal to a circle of known diameter, and with the problem of constructing a straight line equal to a circumference of known diameter. In the early part of this century, there was a very widespread impression abroad that the British Government was offering a reward of half a million dollars for the solution of this problem; and "circle squarers" flocked from all parts of Europe, and even from South America, to claim it. It is hardly necessary to state that no such reward was ever offered. Most of the circle squarers were men utterly ignorant of geometry; some, however, were men of some education, who may very fitly be described as *cranks*.

In conclusion, let us state that mathematicians know all about squaring the circle, that is, about finding the value of π; and this value is of as much importance in other branches of mathematics as in the geometry of the circle. It is a mere accident that this number was defined by its relation to a circle. In this good land, where human life is more highly considered than real estate, it is possible that π might have been differently defined. If Columbus had discovered America earlier, he might have delivered us from circle squarers.

ONE-MILLIONTH OF AN INCH.

G. Herbert Follows.

Surface Plates of the Past Compared With Those of Today—How Standard-Length Bars Are Made—Sir Joseph Whitworth's Measuring Machines.

ONE of the most common machine-shop appliances is the *surface plate*. In some shops it is to be seen on almost every bench. There are various sizes, from the small hand plate used by the maker of fine instruments to the large marking-out table secured to the shop floor.

Now, as the surface plate is used either for testing the flatness of a surface or as a true plane from which to lay off a dimension, it follows that the degree of accuracy obtained from its use depends upon the accuracy of the surface plate itself.

Is there such a thing as a theoretically perfect surface plate? No. A perfect plane, that is, an *absolutely flat* surface, exists only in the mind. It is something we can *imagine*, but that we cannot produce. However, surface plates are now made which approach so nearly to a true plane that, for all practical purposes, they are perfect.

Sixty years ago the process relied upon in

the preparing of surface plates was that of grinding two of them together with powdered emery and water. During the process, each plate was occasionally compared with a so called *standard plane*. This standard,

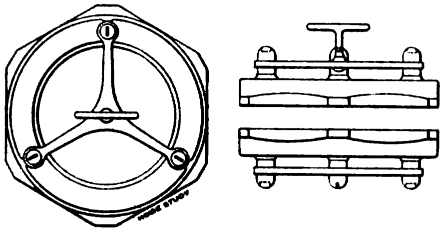


FIG. 1.

however, had itself been produced by the grinding process, and, although very smooth and beautiful to look at, was anything but a true plane, so that, as a standard, it was of no real value. The operation of grinding was bound to fail, because the powder could not be properly controlled, could not be restricted so as to act upon those parts that were in error, but ground away at the whole plate indiscriminately and *never*, by any chance, produced a true, flat surface.

In the year 1840, Sir Joseph Whitworth, of Manchester, England, introduced a new method of preparing metallic surfaces, and submitted specimens of cast-iron surface plates produced by this method. These plates he called *true planes*. They were finished by the process of *scraping*, now well known, but at that time an entirely new departure. The plates were hexagonal in shape, as in Fig. 1. They were mounted upon three equidistant feet, so that, whether put down on an uneven bench or hung up by a tripod attached to the feet, they would be perfectly supported—the same weight being carried by each foot; this prevented

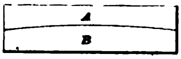


FIG. 2.

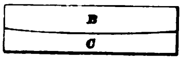


FIG. 3.

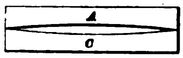


FIG. 4.

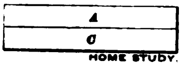


FIG. 5.

distortion of the plates when in use or when hung up out of the way. They were produced in the following manner:

A number of good castings were made, and of them the best *three* were chosen, and their feet and top surfaces planed as accurately as possible. A straightedge was then used to discover which of the three plates was truest. Let us call the chosen one *A*, and the other two, *B* and *C*, respectively. Sir Joseph Whitworth argued that, in order to produce *one* true plane, *three* true planes must be made. The reason for this is best understood by referring to Figs. 2, 3, 4, and 5. If two plates only are used, it is possible for their surfaces to touch all over, but for one of them to be hollowed and the other rounded, as in Fig. 2. With three plates, however, though *A* might fit *B* and *B* might fit *C*, as in Figs. 2 and 3, with still no certainty that any of the surfaces were flat, if *A also* fits *C*, as in Fig. 5, all three surfaces *must* be flat. If not, and *B* were the rounded one, then *A* and *C* would both be hollowed and they would touch on two edges only, as in Fig. 4. By using three plates, then, and making each one fit both of the others, three true planes are produced.

As every machinist knows, the process of scraping is a long and tedious one. The results, however, more than pay for the

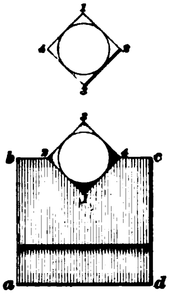


FIG. 6.

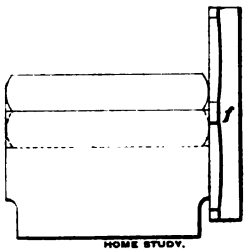


FIG. 7.

trouble, planes being produced which rival in accuracy, though not in polish, the brilliant mirror presented by the surface of mercury when in absolute repose. If two of these planes are pressed together, they adhere, and considerable force is required to separate them. Again, if one of them is allowed to fall gently upon another from some such position as shown in Fig. 1, there is no sharp ring of metallic contact, but a soft, muffled sound, and the upper plate appears to *float* upon the lower one. The first of these phenomena was at one time believed to be due to atmospheric pressure, the second to a cushion of air between the plates. But Professor Tyndall proved, by experiment, that in the most perfect vacuum the adhesion was much the same as in the open air, and the *floating* effect was practically undiminished. The only conclusion to arrive at is that the plates adhere by

molecular attraction because of the perfect contact of so many points in each plane.

Prior to Sir Joseph Whitworth's time, ordinary calipers were used, not only for comparing diameters, but also for measuring end lengths, any desired dimension being taken off the foot-rule with the calipers. The accuracy with which this could be done depended, necessarily, upon the eyesight of the workman and the correctness of the scale which he used. In turning a shaft to any diameter the calipers were the only means of measurement; and, if they were not set correctly, if the workman's sense of touch was dull, or if he failed to hold the calipers at right angles to the axis of the shaft, unknown errors crept in; in fact it was, and is still, impossible to do accurate work by any such means. Whitworth recognized this fact and went to work to produce a measuring machine that would reduce chances of error to a minimum.

Before describing this machine, it will perhaps be as well to explain how the surface plate was used in the production of end-measure bars, which were afterwards employed as standards of length.

First, a block similar to *a b c d* in Fig. 6, was planed up as accurately as possible, and a right-angled V groove cut in it. This groove was made square and straight by means of the most accurate squares and straightedges procurable. Then one end of the block was made as nearly as possible at right angles to the groove. Next, a bar was planed approximately square, and then, by

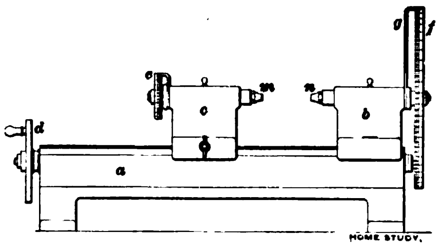


FIG. 8.

scraping, it was made to fit the groove in the block in whatever way it was laid in it. Of course, if each angle of the bar *1 2 3 4* fitted the groove in *a b c d* it was proof that each was a right angle. The end of the bar was then scraped until, when laid in the groove, as in Fig. 7, the surface plate *f* showed that the end was flat. The bar was then turned over and tested again, and, if the surface plate coincided with it as before, it proved that the end of the block *a b c d* was at right angles to the groove, and that the end of the bar was at right angles to the sides. When this state of things was brought about, the bar was turned around and the other end treated in like manner.

In order to obtain a bar of this kind exactly one inch in length, Sir Joseph Whitworth, in 1834, procured from the English Government a standard yard measure. This was in the form of a bronze rod,

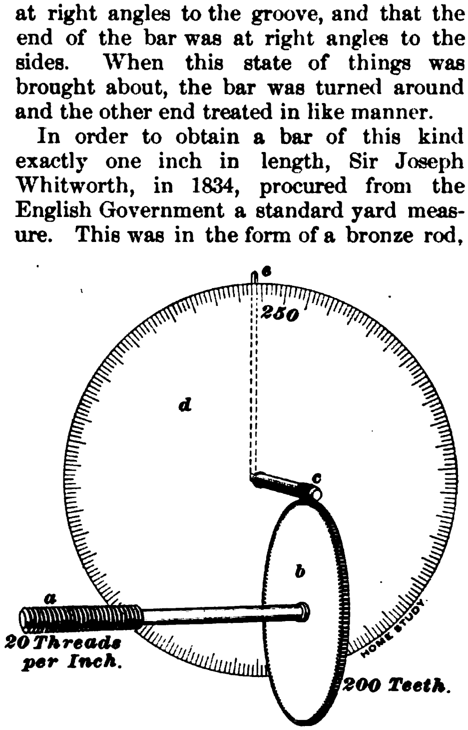


FIG. 9.

of square section, about 38 inches long, inlaid on one face at a distance of an inch from each end with a circular plate of gold. On each of these plates three fine lines were engraved in a direction at right angles to the length of the bar; and the mean distance between these lines was the standard yard.

By the aid of microscopes, this length of one yard was transferred to an end-measure bar such as we have described. Then three bars were prepared, each a little more than one foot in length and these were carefully scraped until the three were equal to each other, and, when placed end to end, exactly equal in length to the standard yard bar. In the same way it was necessary to make twelve end-measure bars one inch long in order to produce *one* which could be looked upon as standard.

A measuring machine was then built capable of detecting an error of $\frac{1}{10000}$ of an inch. This consisted of a bed *a*, Fig. 8, fitted with a headstock *b* which carried a cylindrical spindle *n* which was moved in or out by a screw having 20 threads to the inch. On the end of this screw was a hand wheel *f*

graduated in 500 divisions, which, if rotated through one division, caused the spindle n to move $\frac{1}{10000}$ of an inch. The tailstock c was provided with a spindle m, similar to n, and could be moved bodily along the bed by rotating the hand wheel d. The spindle m could be adjusted approximately by means of the graduated wheel e.

In making this little machine, infinite pains were taken to avoid backlash in any of the parts, and the ends of the spindles m and n, between which measurements were to be made, were scraped perfectly flat and at right angles to the axis of the spindle.

When it was complete, a standard-inch end-measure bar was pinched between the faces m and n with just sufficient grip to hold it there, and it was then made evident, on turning the graduated wheel f and thus releasing the bar, that $\frac{1}{10000}$ of an inch was not by any means the smallest error that such a machine could detect, and preparations were at once made for building a machine capable of detecting a difference of *one-millionth of an inch*. The appearance of this machine was much the same as before, except that the mechanism for actuating the headstock spindle was in principle as shown in Fig. 9, a worm and wheel being introduced between the graduated wheel and the screw. There was a screw a having 20 threads to the inch; on the end of this was a worm-wheel b with 200 teeth, actuated by a worm c; on the same shaft as the worm was the graduated wheel d having 250 divisions. Rotating d through one division caused the headstock spindle to move $\frac{1}{1000000}$ of an inch; thus:

$$\frac{1}{250} \times \frac{1}{200} \times \frac{1}{20} = \frac{1}{1{,}000{,}000}.$$

So accurately was this machine made, so perfectly in contact were the fitted parts, that no backlash could be detected, and measurement to one-millionth of an inch became an accomplished fact.

Of course it is seldom necessary, in the machine shop, to measure one-millionth of an inch. A man who can work to a "thousandth" is considered reliable enough, but to do even this he must provide himself with micrometer calipers (which are exactly similar in principle to Whitworth's measuring machine) and take all his measurements from gauges and end-measure bars.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

Porto Rico.

THE late war between the United States and Spain was begun somewhat hastily, and the anticipated victory was won so rapidly that the conflict has already received the appellation of "The War of a Hundred Days." But though far more than a hundred days have elapsed since the suspension of hostilities, this nation, like all others in similar circumstances, must wait a long time before the national bookkeepers can submit to it a fair balance sheet, on which profit and loss can be so clearly displayed that he who runs may read. With regard to certain items, opinions differ as to whether they shall be placed on the debit or the credit side of the ledger. All know on which page to write the valor of our soldiers and sailors, and the increase of our prestige in the family of nations, won by the skill and courage of a few men whose names have become world-renowned. We know, also, where to place the lives that have been sacrificed—legitimately and illegitimately; the maimed bodies, the enfeebled constitutions; we set down the figures of our pecuniary indebtedness without hesitation in the proper column; and between items such as these a balance can be struck, showing profit and loss.

But on which page shall we place the territorial acquisitions of the United States? Without considering the future of the Philippine Archipelago, we come out of the war with an outpost established on either side; the Hawaiian group in the western, and Porto Rico in the eastern, ocean. Most wars involve the transference of territory from one government to another, and most victorious nations accept their new responsibilities as a matter of course, and with more or less of satisfaction. But the rank and file of the people of the United States manifested surprise when they found that, having interfered

with Spain's island possessions, reason and necessity demanded from this country a decision as to their future disposition. The voices of the best statesmen of the country have been heard on both sides of the question; some claiming for the republic its heritage of expansion, and the blessings of freedom for those whose fate has been placed in our hands; others repudiating the idea that any outwork is needed for a nation whose dominions are already within a ring fence, and asserting that we are "not as other men are," but that we went to war in a spirit different from, and loftier than, that of mankind at large; and that if we accept accessions of territory we shall be false to our professions, and compromise the principles and the best interests of our country. Solid arguments, based on reason, on prudence, and on conscience, have been adduced on either side; and we have a striking illustration of the fact, constantly forgotten between man and man, that two opinions may be honestly entertained on the same question at the same time by sensible people.

It has long since appeared to be the destiny of Hawaii to become attached, at some time and in some way, to the United States; and as an accident of the late war she has now been received as a self-invited guest, seeking a permanent home. Porto Rico, on the contrary, as the property of an impecunious debtor, has been attached by the creditor nation, with hardly a sign of opposition on the part of its nine-tenths of a million of inhabitants, who thus come under the rule of their powerful neighbor with a status as yet undetermined. Are they citizens, or colonists, or a subject race? The constitution of the United States makes provision only for the former class. If the Porto Ricans have become American citizens in virtue of the annexation of their island, to what extent are they entitled to exercise the privileges of citizenship? What are their civil rights? What their powers of local self-government? Must they give their consent to their transfer to a foreign flag by taking an oath of allegiance before they can claim its protection? All these questions, and many more, await decision by constitutional means on the part of the United States. The stars and stripes were raised over the island on October 18th, 1898. A provisional government has been established, and it remains for the citizens of the ruling nation to take stock of their new acquisition, and decide how it shall be administered.

Porto Rico is smaller than any of our states, excepting only Delaware and Rhode Island; and these two combined would about equal it in area. A range of hills crosses the island from east to west, and these hills intercept the rain clouds borne by the northeast trade winds, so that the moisture which they carry is deposited, and the island on the northern side is remarkably well watered. It is also well wooded, and, according to an old colonial law, he who cuts down a tree must plant three in its place. The law, while not fully enforced, has its influence. The soil is divided between many small cultivators. A traveler, whose account in other respects indicates careful observation, makes the astonishing statement that in 1834 there were in the island 19,000 proprietors of land. Coffee, sugar, and tobacco are the most valuable products as articles of export, but the fertile soil will produce all that is necessary for the comfortable support of its population. Home-grown rice is largely used for food, and pasturage for cattle abounds on the lowlands near the northern coasts.

Porto Rico has advanced rapidly in prosperity and in population during the present century. Part of this increase is due to immigration from South America between the years 1810 and 1825, when the Spanish colonies there were being gradually transformed into republics. Less than half the population consists of negroes and of mixed races, according to the census returns; but it is believed that many of those who claim to be of pure Spanish descent have really a strain of negro blood. Traces are still to be seen of the old original Indian stock; and when their characteristic features are found, employers have learned to expect superior work, and a disposition of kindliness and helpfulness towards one another. Slavery existed until 1873. The provision for its abolition was one of the first important public acts of the Spanish government during the short-lived republic of 1873–1876. Immediate emancipation was ordered, but the slaves were required to serve as hired laborers for three years, and were not to receive political rights until five years had expired. The masters were indemnified by the Spanish government, and immigration of labor was discouraged by the authorities in order that employment for the emancipated slaves might be available.

With the increase in population and in prosperity there has naturally been a change for the better in the social conditions of the people. In the middle of the last century there was no social life. Then the people

lived apart; their homes were rude hovels, without windows or doors to close the necessary apertures; or else a thatch of leaves and branches supported on poles. Many dwellings (so called) of the latter description are still to be seen. They had hardly any utensils; an empty bottle became a precious heirloom. Now, a majority of the population live in towns, all of which are connected by roads, though there is room for much improvement in this direction. There are about 150 miles of good highway, of which more than half, including the 80 miles which connect San Juan with Ponce, is admirable and well kept. Other roads are fit only for ox teams, or for travelers on horseback. A French construction company has laid out a railroad, following the shore line, with branch lines to inland towns. Of this, only such portions have been built as present few engineering difficulties; but 130 miles are said to be open for use, and about 500 miles of telegraph and telephone wires have been laid. The general average of education in the island is so low that very little use is made either of the wires or of the post office. The returns of the census of 1887 state that one-seventh of the population could read and write. The average is higher in the towns, for recent visitors say that in country districts ninety-seven per cent. of the people are illiterate. Public instruction, however, is improving year by year.

San Juan, the capital, founded in 1511, is a very interesting specimen of a medieval walled town, and as such is a valuable addition to Uncle Sam's curiosity shop; for only as a curiosity, or as an object lesson for the student of history, can these fortifications be of value in these days of modern artillery. There are the walls, the battlements, the moat, the gates, with portcullis and drawbridge, as planned and begun in 1534. Valueless as they now are as means of defense, they have seen active service, and besiegers have been repelled and property protected in many attacks by the British and by the Dutch. Within the walls San Juan is laid out with streets at right angles, like a modern American town. Its situation, on the point of an island formed by a coralline reef, is fine; its soil is healthy; it is in the path of the trade winds, and an ocean current sweeps through its harbor; the pavements of the main streets are good and carefully cleansed. Yet epidemics are frequent; vermin abound; the dreaded typhoid is a familiar visitor. This must mainly be attributed to the character of the water supply, which consists of rain from the roofs, preserved in cisterns, generally situated in the center of the courtyard around which each house is built. There is practically no system of sewerage, and the conditions of life of the negroes and the other poor are crowded and extremely unsanitary.

There are many other towns in this populous little island; fourteen of them are of sufficient importance to possess a customhouse; and trade only awaits the quickening influence of peace and freedom to grow and flourish. Ponce, which is larger than San Juan, is also a more desirable residence for the American. It has an aqueduct, with fine water supply; and its climate, warm, though not oppressive, is tempered by sea breezes during the day, and by a land breeze at night. Its hot springs are reputed to possess many virtues; and with their aid, supplemented by the application of modern sanitary science, Porto Rico may ere long take its place among the health resorts of America.

COOKING FOR SICK PEOPLE.

Mrs. Henry Esmond.

SHOULD BE APPETIZING IN APPEARANCE, AND DAINTILY SERVED—THE PREPARATION OF GRUELS, BEEF TEA, AND BROTH—RAW-BEEF SANDWICHES—SOOTHING DRINKS.

WHEN preparing food for the sick, everything should be made to look as attractive and appetizing as possible; otherwise, the patient will not care to taste it. Very often, the appetite of a sick person has to be coaxed back, and the nurse should make it a point to see that the food is served daintily, that it is hot or cold—whichever it is intended to be—not half way between, that it is served promptly, and that all traces of it are removed from the room immediately after the patient has finished.

When serving broth or gruel or any hot drink, bring it into the sick room in a hot

pitcher, and pour a little at a time into a warm cup. Your patient will take more if it is served in this way than if you bring him a large bowlful that would do for a strong, healthy man.

In making gruels, allow 1 tablespoonful of meal or flour (or whatever the gruel is to be made of) to every cup of liquid. Always use half milk and half water; for instance, if you wish to make Indian-meal gruel, take 3 tablespoonfuls of meal, 1½ cups of water, 1½ cups of milk, and ½ teaspoonful of salt. Have the water bubbling hot, and add the meal, which has previously been moistened with cold water. Let this cook for 20 or 25 minutes, and then add the salt and milk. It is always best to cook gruels in a double boiler; there is then no danger of burning.

In using any fine meals—such as Indian meal, wheatlet, or farina—it is best to moisten with cold water before attempting to mix them in the boiling water; this prevents them from lumping.

Beef Tea.—Take 2 pounds of lean, juicy beef—round steak is best; cut it into small pieces, put into a glass jar, and pour over it 1½ cups of cold water. Let it stand for 2 hours, and then place the jar in a towel in a kettle. Screw the top on the jar and fill the kettle with cold water; set it on the back of the stove, and let the water heat gradually—but never boil. Let it cook this way for 2 hours, or until the meat is white. When it is done, strain and season with salt. Great care should be taken not to heat the water too suddenly, as it will then cook the beef tea and coagulate the albumen in the beef, and the tea will then look curdled. If you wish to obtain pure beef essence, do not add any water to the beef in the jar.

Broth.—For broth, get lean, juicy meat—beef or mutton. Remove whatever fat there is, and chop the meat. Add cold water—1 pint of cold water per pound of meat—and let it stand until the water is red; then let it simmer for 15 or 20 minutes. Strain it and season with salt, and thicken with a little flour, or add some boiled rice or barley. If after it is cooked any fat still remains on top of the broth, can be removed with a piece of blotting paper or other spongy paper.

In making chicken broth, let it cook until the chicken meat drops from the bones; then strain and season with salt, and stand away to get cold, when it will jelly, and all the fat can be removed.

Soothing Drinks.—Pour 3 cups of boiling water over ½ cup of either flaxseed or Irish moss, or over ½ ounce of slippery-elm bark (if you use the moss, first wash it thoroughly). Stand on the back of the stove for 3 hours, then add the juice of 2 lemons and ¼ cup of sugar. Strain and cool. These drinks are invaluable in cases of tonsilitis, a sore throat, or a bad cold on the chest.

Egg Nog.—Beat 1 egg very light; add 1 tablespoonful of sugar, and 2 tablespoonfuls of sherry or brandy; put this into a glass, and fill it up with cold, sweet milk.

Sometimes, when very sick, a patient will take the white of an egg beaten stiff, with ½ teaspoonful of sugar and 2 tablespoonfuls of port wine. This is very strengthening.

A convalescent can generally eat a little beef or a chop or some small bird. The best way to cook these is to broil them. In preparing a small piece of beef, instead of leaving it in the solid piece, take a sharp knife and scrape it; in this way you get the juice and all the pulpy part of the meat, without the stringy fiber. Shape this pulp into little cakes, and put in a buttered paper and broil; season, and serve hot.

In broiling any meat or birds for a sick person, always cook in little paper cases. To make these cases, take one leaf of a piece of note paper, butter it, and fold it over as you would fold a letter for a square envelope; put the piece of meat in this, and fold the edges over twice all around, thus forming a case. Place this on the broiler and broil over a hot fire. This prevents the meat from getting smoked or burned. Quail, squab, or any small bird is better boned, as are also chops.

Raw-Beef Sandwiches.—Scrape a piece of lean, juicy, raw beef and spread the pulp on a thin slice of bread; sprinkle a little salt on the meat, cut in half, and put together like any meat sandwich. A patient can often eat meat in this form when he will not touch cooked meat.

Jelly.—Soak ½ box of good gelatine in ½ cup of sherry wine; when the wine is all soaked up, pour on ½ cup of boiling water and stir until all the gelatine is dissolved; then add 1 pint of sherry and the juice of 1 lemon, and ½ cup of sugar. Strain into a bowl, which has been wet in cold water and set away to chill. In making lemon or orange jelly, soak the gelatine in cold water, then pour on 1 cup of boiling water and the juice of either 3 lemons or 3 oranges; add ½ cup of sugar, strain and chill. Always wet the bowl or mold in cold water before pouring in the jelly; otherwise, it will not turn out easily. Do not use more than ½ box of gelatine, as the jelly should not be too stiff.

A FAMOUS LOCOMOTIVE.

THE ANNEXED illustration shows an engine that enjoys the distinction of having the largest pair of drivers in the world. It is one well known to English locomotive men as the old "Cornwall," belonging to the North Western Railway, England. It was built at Crewe by Trevithick, in 1847. It now presents a very different appearance, however, from what it originally did, for, as first constructed, the boiler was placed wholly beneath the driving axle. In those days locomotive designers were afraid to set their boilers very high, fearing that they would be top-heavy, and therefore unsafe at high speeds—at least on a narrow-gauge road, that is, a 4′ 8½″ gauge. As, however, they wished to secure plenty of heating surface, and consequently to use what at the time seemed to them a large boiler, they were afraid to put it in the usual position (above the axle), so they put it underneath. The drivers were (and are now) 102 inches in diameter; the cylinders were 17½ in. × 24 in., outside, of course. The engine not proving a success, it was reconstructed, appearing as in the figure. In such shape, it may still be seen running on one of the branch lines of the North Western, being, of course, altogether inadequate to present-day needs, as regards main-line express traffic.

While having the largest drivers of any engines now running, yet they are not the largest ever used, although such is usually believed to be the case. In 1853, some express tank engines, having 108-inch drivers, were built for the Bristol & Exeter Railway, England. This was a "broad-gauge" road, that is, 7 feet wide, as distinguished from the "narrow-gauge," 4 ft. 8½ in. wide. The cylinders were 16½ in. × 24 in. The engine had a four-wheeled truck, back and front, the drivers being placed between them; the truck wheels were 48 inches in diameter. This engine reached a speed of 80 miles an hour, and did her ordinary work on less than 22 pounds of coke per mile.

ICE MAKING AND REFRIGERATION.

DURING the past few months we have received many inquiries relating to ice-making and refrigerating plants. The majority of the questions we have been unable to do anything with, because they were of so general a character that adequate answers would have occupied far too much space. We recommend those who are interested in the subject to procure a copy of "The Practical Running of an Ice and Refrigerating Plant," by Paul C. O. Stephansky; price $2.00. Angel Guardian Press, Boston, Mass. In this book the subject is treated from the standpoint of the practical man, and is finely illustrated.

WORLD-WIDE PHOTO EXCHANGE.

THE above is the name of a society, founded February 1st, 1898, whose object is to promote correspondence between amateur photographers, and to facilitate, by its influence, the exchange of photographic prints, ideas, schemes, formulas, experiences, and methods between its members in different parts of the world. It also aims to enable its members to collect photographs of anything strange, odd, or interesting—historical buildings and places, battle-fields, lakes, mountains, and fine scenery of all kinds, and, above all, specimens of excellent and artistic photography made by its members. It is, in effect, a continuous photographic convention,

and it is admitted that more useful photographic information may be secured by correspondence and the exchange of prints than by any other method, save, perhaps, expensive attendance at the various photographic conventions. The society publishes on the first of every month a list of all members who have joined during the month previous. Each member is given a number, and to his name is appended a list of his cameras, size of prints, and an idea of the subjects he has to exchange. The exchanging is done by direct correspondence on any agreed basis. Upon request any special terms of exchange will be inserted in the list, at the time the name appears. Each member receives a copy of this list on its publication during the time for which he joins the society. The dues for twelve numbers of the list and one notice is 25 cents. President, F. D. Sawyer, Otisfield Gore, Me.; secretary, F. R. Archibald, Rock Creek, Ohio.

THE ELECTRICAL EXHIBITION COMPANY.

At the annual meeting of stockholders of The Electrical Exhibition Company, held November 21, 1898, it was unanimously decided to hold another electrical exhibition in New York City in 1899. The following officers and directors were elected: C. O. Baker, Jr., president; F. W. Roebling, vice-president; Geo. F. Porter, secretary and treasurer; H. H. Harrison; L. F. Requa, J. W. Godfrey; C. A. Lieb; Marcus Nathan, general manager.

THE CROSS OIL FILTER.

Every user of lubricating oil knows that the amount of oil actually consumed by the machinery on which it is used is but a small proportion of the whole amount that he buys; that, but for the fact that dirt and grit get into it, it could be used over and over again, instead of being thrown away as waste oil. This waste, the lubricating qualities of which are not affected in the least, frequently amounts to 75 per cent. of the oil used; if the impurities are eliminated, the oil is practically as good as new. But the impurities do not consist alone of dirt and grit. Mineral acids are formed during the use of the oil, and these, together with the free fatty acids which nearly always exist in oil that has been used, must be wholly removed.

The Burt Manufacturing Company, Akron, Ohio, are the makers of the Cross oil filter here illustrated. It is claimed that chemical tests of oil before and after filtration demonstrate that this filter does remove the acid and makes the oil as good and as fit for use as on the day it was shipped from the refinery.

The operation of the filter is as follows: The bottom chamber *E* is filled with pure, warm water, the temperature being regulated by means of the steam coil shown. Very little steam is required, and, if the filter is kept in a warm place, it may not be necessary to make steam connection at all. The oil to be cleansed is poured into chamber *B* through the top grating. It then passes through the layer of waste, which collects all the heavy impurities. From there, through the perforated bottom of chamber *B*, the oil passes into tube *C* in the manner indicated by the arrows. The oil, being lighter than the water in *E*, has a tendency to rise, but the head of oil in *B* forces it down until it escapes from the bottom of tube *C* and runs out against the *under* side of the filter plate *D*, spreading over this plate in a very thin film, which constantly changes surface, and diminishes in thickness as it travels outwards towards the circumference of the plate. Thus, every particle of the oil is exposed to the action of the water. Escaping from the edge of plate *D* it rises, is intercepted by plate *1 D*, which is so deflected as to compel the oil to flow towards the center, whence it rises, as indicated by the arrows, to plate *2 D*. It here receives final washing, then rises through waste in *F* to the oil chamber *G*, and is drawn off as required from cock No. *1*.

RENSSELAER POLYTECHNIC INSTITUTE.

The Annual Register of the Rensselaer Polytechnic Institute, Troy, N. Y., with a register of graduates of 1826–1897, has been issued. The register contains the general information concerning courses of instruction, requirements for admission, etc. usually given in college catalogues. The leading course of instruction is that in civil engineering, leading to the degree of C. E. (Civil Engineer); a subordinate course in natural science leads to the degree of B. S. (Bachelor of Science). We note, also, a special lecture course in railroad block and interlocking systems, a summer course in surveying and railroad engineering, and a special winter course in highway engineering and road construction. While the primary object of the Institute is to give instruction in civil engineering, the training of the student is of such a character that he is fitted to engage successfully in almost any of the numerous branches of engineering. In this connection we cannot do better than quote the following from the register: "The studies of the course are designed to secure to all the graduates a professional preparation, at once thorough and practical, for the following specialties of engineering practice: the location, construction, and superintendence of public works, as railways, canals, water works, sewerage systems, etc.; the design, construction, and management of mills, iron works, steel works, chemical works, and pneumatic works; the design and construction of roofs, arch bridges, girder bridges, and suspension bridges; the survey and superintendence of mines; the design, construction, and use of wind motors, hydraulic motors, air engines, and the various kinds of steam engines; the design, construction, and use of machines in general, and the determination of their efficiency; the survey of rivers, lakes, and harbors, and the direction of their improvements; the determination of latitude, longitude, time, and the meridian in geographical explorations, or for other purposes, together with the projection of maps; the selection and test of materials used in construction; and the construction of the various kinds of geometrical and topographical drawings." The Troy Institute has always been noted for the efficient character of the instruction given. The managers of the Institute seem to have realized that engineering is more a science than an art, and that in so far as it is an art it must be founded on scientific principles. As a result, the greatest attention is given to general principles and general methods, rather than to narrow and so called "practical" facts. The almost universal success of Troy graduates in their chosen profession testifies to the wisdom of this scientific system of instruction.

A NEW FEEDWATER HEATER.

The Robertson Manufacturing Co., 204 Fulton Street, New York, N. Y., in presenting the "New World" return copper coil feedwater heater, claim that it is the embodiment of all that is perfect in a device of this kind. The improvements introduced in this heater will be understood from the accompanying illustration. It will be noticed that the water inlet and outlet are both located at the lower part of the shell, but on opposite sides, thus greatly simplifying the "piping up" of the apparatus. The coil is made from the best seamless copper tubing, and is of such dimensions as to insure the instantaneous heating of the feedwater to a temperature of 210° Fahrenheit. The feedwater is carried through the coil to the top of the heater; then, by means of a patent expansion return so constructed as not in any way to retard the flow of water or increase the friction, it passes down to the point of discharge at the bottom of the shell, where it meets the exhaust steam, thus getting the benefit

of the hottest steam, both when entering and when leaving the heater. In passing through the heater, the water does not come in contact with any metal other than copper; thus rusting out is impossible, and galvanic action is prevented. The coil is free to expand and contract both lengthwise and spirally, yet at the same time it is so braced that chafing and vibration are impossible. The details of construction in this heater have received the most careful attention, the object being to place on the market a perfect device.

CAMERAS FOR 1899.

The Eastman Kodak Co., Rochester, N. Y., issues an attractive catalogue of their world-famed kodaks and photographic sundries. Every variety of kodak is illustrated, for either plates or films, or both; there are pocket cameras, folding cameras, and ordinary cameras; bicycle camera cases of many kinds; tripods; developing outfits; dark-room lamps, etc., etc. Amateur photographers, or those who think of becoming such, should send for a copy. "Pictures by Flash Light" is the title of a little book published by the above company, which is written specially for beginners.

THE MICHIGAN COLLEGE OF MINES.

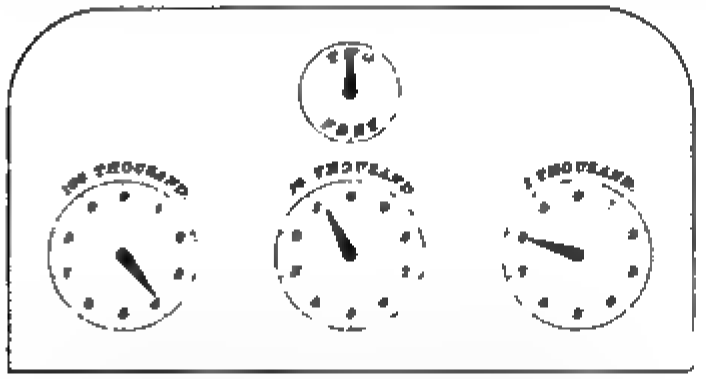
The 1896–1898 catalogue of this college gives a very favorable impression of the character of this famous school. The courses of study are complete and appear to be very judiciously arranged. One specially commendable feature of the instruction is the treatment of the vexed shop-work question. Many of our best engineering schools are seriously crippled, as regards time, by the necessity of giving 10 to 15 hours per week throughout the 4 years to practice in the shops and laboratories, to surveying, etc. While no one doubts the desirability of such manual training, it is frequently the case that the large amount of time required in this work necessitates hurried and unsatisfactory work in mathematics, mechanics, drawing, and other fundamental studies of infinitely greater importance than manual training. In the College of Mines, the school year is divided into four terms. During the first three terms—33 weeks—the time is entirely occupied in collegiate studies, and no attention is paid to shop work; but during the fourth term of 12 weeks, all of the time is devoted to shop practice, surveying, ore dressing, testing materials, etc. This seems to us an ideal solution of the shop-work problem. The Michigan College of Mines has an enviable and a deserved reputation for thoroughness and good teaching. It is situated at Houghton, in the northern peninsula of Michigan, in the midst of some of the largest and deepest iron and copper mines in the world. The catalogue may be obtained by applying to the president of the school, Dr. M. E. Wadsworth, Houghton, Michigan.

COLUMBIA CALENDAR.

The Pope Manufacturing Co., Hartford, Conn., are now distributing the Columbia calendar for 1899. This is the fourteenth edition of a very useful little memorandum pad, and is fully up to the standard of excellence set by its thirteen predecessors. It is of distinctive value for busy men and women.

Engagements to be made and duties to be performed can be jotted down on its leaves, and the daily reminder will save much annoyance and inconvenience. The bright and witty sayings and fitting testimonials to the merits of Columbia products, which grace the tops of the pages, are largely contributions from the company's own customers, and give an added value to the calendar. The pages for Sundays, the first day of each month, and holidays, present appropriate selections from well known authors. The calendar will be mailed to any address, safely packed in a carton mailing case, on receipt of five 2-cent stamps, at the Calendar Department of the Pope Manufacturing Co., Hartford, Conn., or a copy can be procured by applying to the nearest Columbia dealer.

NOTE.—In HOME STUDY MAGAZINE, December, 1898, article entitled "The Gas Bill," the reading of a meter is explained, and the reading from Fig. 2 is given as 41,800. This reading is incorrect. It should be 40,800, and was written so in the author's manuscript. Several of our friends have kindly drawn our attention to this mistake, while others have suggested 30,800 as the correct reading. As there is some misunderstanding regarding the method of reading the dials, it will not be out of place to explain a little more fully how the 40,800 is found. The accompanying figure is the one already referred to. Let us go by the author's rule, "first write down from each dial the figure which the pointer



has just passed." (Thus *3, 0, 8* are the figures shown), "then annex two ciphers to the right" (thus 30,800). "the number so obtained will be the amount of gas in cubic feet which the meter has measured" But let us draw attention to the pointer on the *100 Thousand* dial; this has nearly but not quite reached the notch at the figure *4*. The correct place for this pointer is a little *beyond* the *4* mark, but it must be understood that meters are not all made like stop-watches. The pointers do not all point to exactly the right spot; sometimes there is a little play in the gears, and frequently the pointers are also a little off either one way or the other; they are, however, close enough to let the reader understand which figure to work from Now, what the author means by the words, "which the pointer has just passed," is, "*which the pointer should have passed if the registering mechanism is perfect*" In order to determine whether a pointer has passed a given figure or not, the meter reader must refer back to the dial preceding it. Thus, in the figure, if he is not sure whether the pointer has passed the *4* mark on the *100 Thousand* dial, he must refer to the *10 Thousand* dial, and there he will find a solution of the problem, because the pointer has just passed the zero mark. The pointer on the *100 Thousand* dial is about 9,000 cubic feet nearer the *4* mark than it is to the *3* mark. This means that the pointer is not mathematically correct, but is close enough for an intelligent reading. We may add that the pointer was intentionally misplaced a little, so as to more closely resemble an average meter dial.

(536) I have discovered that, if a bar of iron be heated at one end, the other end being held in the hand until the whole piece becomes quite warm, and is then plunged into water so that, with the exception of the part held in the hand, the rod is wholly immersed, the temperature of the upper end rises until it becomes too hot to hold. Can you explain this? J. B., Bridgeton, N J.

ANS.—Heat always passes, or tends to pass, from hotter to colder bodies, or from the hotter to the colder parts of the same body. When the bar is immersed in water, all its heat does not pass suddenly into the water; it passes comparatively slowly from the hot part of the bar both into the water and into the colder part of the bar, and, therefore, the latter will undergo a change of temperature, which may be very great, as, when the difference between the temperature of the water and that of the heated part of the bar is small.

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(537) Given an ordinary barrel filled with water, closed with a plug, and standing on end. Screw into the upper end a half-inch pipe having a perpendicular height of 30 feet, and fill this pipe with water. Will the weight of the water in this pipe tend to burst the barrel, and what increase of pressure will it cause on the bottom, sides, and top of the barrel, the temperature remaining constant? G. W. T., Fall River, Mass.

ANS.—Let *h* be the height and *d* the diameter of the attached pipe, both in inches, and *w* the weight of a cubic inch of water. The increase of pressure per square inch on the sides and ends of the barrel is equal to the weight of the column of water in the pipe divided by the area of the cross-section—that is, to the pressure exerted by the water in the pipe on every square inch of its base. This is equal to

$$\frac{\frac{\pi}{4} d^2 \times h \times w}{\frac{\pi}{4} d^2} = h \times w,$$

and is seen to be independent of the diameter of the pipe. The value of *w* is .036 pound, nearly. In the present case, therefore, the increase of pressure is $30 \times 12 \times .036 = 12.96$ pounds per square inch. This pressure will, of course, tend to burst the barrel.

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(538) While reading M. N. Forney's "Catechism of the Locomotive," Part V, question 59, I came across the following "Low pressure of steam can be exhausted more quickly through a cylinder than steam at a high pressure, and, consequently, there is less resistance, or back pressure." Is this so, and why? F M F, Brooklyn, N. Y.

ANS. The reference you give does not agree with our copy of "Forney," so we cannot tell if you have quoted him correctly The statement, as you have it, is not very well put. If we have two equal cylinders *A* and *B*, containing steam at 100 pounds and 25 pounds pressure, respectively, the velocity of flow from *A* will be greater than that from *B*. But there is more steam in *A* than in *B* (that is, a greater *weight* of steam), so that it will not necessarily empty itself

NOTE.—For conditions to be observed by subscribers wishing to have questions answered in this department, see contents page.

the more quickly of the two. Or, we may look at it thus: When A has exhausted such an amount as will bring its pressure down to 25 pounds, it is then only in the condition that B was at the start, and B has been exhausting right along also. Evidently, then, A cannot catch up with B; in other words, B will discharge its contents first. If the cut-off and the design of the valve are the same in each case, the back pressure and the compression will be greater in A than in B. In A the pressure at cut-off is greater than in B, and, the exhaust opening at the same time, the pressure at that point is greater also. Thus, the back pressure is greater throughout the return stroke. Again, as the exhaust closes at the same time as in B, the compression is also greater. In each case, the same *volume* of steam is bottled up, but it is at a higher pressure, and therefore there is a greater weight of it in the one case than in the other.

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(539) If a monkey sits on top of a post, and a man walks around the post, the monkey all the while keeping his face towards the man, does the man walk around the monkey? L. G. R., St. Louis, Mo.

ANS.—Yes. In walking around the post—which you will grant the man does—he also walks around everything that is *on* the post.

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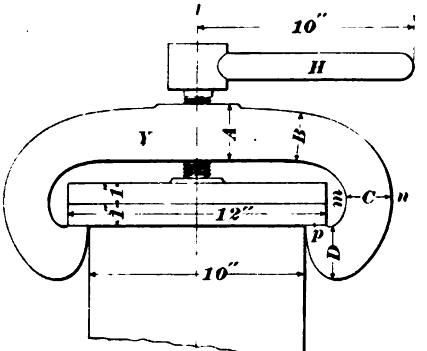
(540) The enclosed sketch shows how I must fasten the bonnet to a strainer by means of the malleable-iron yoke Y. Can you tell me how to calculate the dimensions A, B, C, and D?

L. P. M., Philadelphia, Pa.

ANS.—We will first deal with the stress at A, calculating the required section at that point. The screw measures 1¼ inches in diameter; the pitch therefore is $\frac{1}{7}$ inch, assuming it to be a standard thread. While the handle H rotates once, the screw descends through $\frac{1}{7}$ of an inch, and correspondingly for smaller movements of H. Assume the greatest effort likely to be imposed on H to be 20 pounds, and



applied at a point 8 inches from the center of the screw. As to the loss of power through friction of the thread in the yoke, and of the point of screw on the bonnet, we will assume it to be 65 per cent.; that is, .35 of the power exerted is available in tightening up. We then have

$$8 \times 2 \times 3.1416 \times 20 \times .35 = \tfrac{1}{7} \times x,$$

where x is the force in pounds with which the screw presses down on the bonnet. From the above we find that $x = 2{,}463$, or, say, 2,500 pounds. Half of this amount comes on each foot of the yoke. Now, the 1,250 pounds at the end D may be regarded as all applied at the point p, 5½ inches from the center line ll. The section A is, say, 1½ inches from ll. The distance from p to A is therefore 4 inches. The stress induced at A by the load at p is met by the resistance to distortion of the metal at A. Assuming a rectangular section of breadth b and depth d, and equating the bending moment and the moment of resistance of the section at A, we have

$$1{,}250 \times 4 = \tfrac{1}{6}\, b\, d^2 f.$$

($\frac{1}{6} b d^2$ is obtained by dividing the moment of inertia $\frac{1}{12} b d^3$ by the distance of extreme fiber from the neutral axis $\frac{d}{2}$.) Take f, the working stress in pounds per square inch, as 6,000. Then,

$$b\, d^2 = \frac{1{,}250 \times 4 \times 6}{6{,}000} = 5.$$

If we take b as ¾ inch, then $d^2 = \frac{5}{.75}$, or $d = \sqrt{6.67} = 2.58$, or, say, 2⅝ inches. Hence, the section at A is 2⅝ in. × ¾ in. We will now deal with the section at C. Having found A and C, the outline of the yoke may be put in by eye. At C, then, is a tensile stress distributed over the section, due to pull of screw. There is, in addition, a bending action, due to the pull not being in line with C but to one side of it; the tendency of this is to straighten the yoke out, in the same way that a crane hook tends to straighten out under its load. The stress at C, due to the dead load (the pull of screw) is $\frac{1{,}250}{b\,d}$, denoting the breadth and depth by b and d, as in the case of A. The stress due to bending is a tensile one at m, and a compressive one at n, the net effect being an increase of the pull at m, and a decrease of that at n. The distance between p and the center of section at C is, say, 2½ inches. We must bear in mind the clearance between the yoke and the flange. We already have an idea of what the width of C will be—judging from that of A—and we locate its center accordingly, and thus obtain its distance from p. If, on working out, the calculated width should prove too great to obtain the necessary clearance, we could set the yoke out a little, and make it a little wider, or else recalculate. The moment of inertia of the section is, as before, $\frac{1}{12} b\, d^3$, the induced stress at m is

$$\frac{1{,}250 \times 2.5 \times \frac{d}{2}}{\frac{1}{12} b\, d^3} = \frac{17{,}750}{b\, d^2}.$$

The total stress =

$$\frac{1{,}250}{b\, d} + \frac{17{,}750}{b\, d^2} = \frac{1{,}250\, d + 17{,}750}{b\, d^2}.$$

Equating this to the allowed fiber stress, and simplifying, we have

$$6{,}000\, b\, d^2 - 1{,}250\, d = 17{,}750;$$

or,

$$25\, b\, d^2 - 5\, d = 71.$$

If, as before, we let $b = \frac{3}{4}$ inch, we have

$$d^2 - \tfrac{4}{15} d = \tfrac{284}{75}.$$

Solving this quadratic we find $d = 2.08$, or, say, 2⅛ inches. The section at C is, therefore, to be 2⅛ in. × ¾ in. The yoke can now be finished by eye. It is advisable to make the foot wider than the body of the yoke, to give it more stability—more especially as the yoke is a casting and not a forging. That is, make the part p, where it takes its bearing on the flange, about 1¼ inches wide, running it off—not too abruptly—into the ¾-inch body.

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(541) Kindly answer the following questions, and in each case give me what rules and formulas you can: (*a*) Studs 1¼ inches in diameter are to be used for securing a cylinder head; the steam pressure in the cylinder is 90 pounds per square inch; the stress per square inch of section in the studs must not exceed 1,800 pounds: How many studs will be required? (*b*) If a cylinder head is secured by means of twenty-two 1¼-inch studs, and the pressure of steam in the cylinder is 90 pounds per square inch, what must be the diameter of the cylinder in order that the stress per square inch of section in the studs shall be 1,800

pounds? (*c*) A crown sheet is 6 ft. 6 in. × 9 ft. 9 in., it is subjected to a steam pressure of 90 pounds per square inch. What is the total pressure on the plate? (*d*) A 4¼-inch safety valve must blow off at 85 pounds steam pressure; I wish to use ¾-inch steel for the helical spring. What must the outside diameter of the spring be? (*e*) A brace 2⅝ inches wide by ⅜ inch thick is fastened to a boiler plate by 4 rivets; the steam pressure is 65 pounds gauge. What must be the diameter of the rivets? (*f*) What is the greatest allowable pitch for 1¼-inch stays in a boiler working at 60 pounds gauge pressure? (*g*) How is the length of a connecting-rod found? M. M., Duluth, Minn.

ANS.—(*a* and *b*) The stress you limit yourself to is very small. If the studs are of steel you may allow a working stress of 5,500 pounds per square inch of net sectional area; if of wrought iron, allow 4,500 pounds. The area in question is that taken at the bottom of the thread; for a 1¼-inch thread this area is .893 square inch. You do not give diameter of cylinder in (*a*).

Let D = diameter of cylinder in inches;
- A = area of cylinder head in square inches;
- P = steam pressure in pounds per square inch;
- a = sectional area of stud at bottom of thread in square inches;
- n = number of studs,
- f = working stress in stud in pounds per square inch.

The load on the stud due to steam pressure is $A \times P$. The working resistance of the studs is $a \times f \times n$. Therefore,

$$A\,P = a\,n\,f;$$

whence,

$$n = \frac{A\,P}{a\,f}. \qquad (1)$$

Again, writing $.7854\,D^2$ for A, we have

$$.7854\,D^2\,P = a\,n\,f;$$

whence,

$$D = \sqrt{\frac{a\,n\,f}{.7854\,P}}. \qquad (2)$$

Formula (1) will give what you want in (*a*), while (2) will do for (*b*). (*c*) Multiply the area of the sheet by the pressure on a unit of the surface.

Area in square inches = 78 × 117 = 9,126.

Total pressure on sheet = 9,126 × 90 = 821,340 pounds.

(*d*) Let
- A = area of valve in square inches;
- P = steam pressure in pounds per square inch,
- d = diameter of spring steel;
- D = diameter of coil of spring (reckoned from center to center of the wire).

Then the formula $D = \frac{8{,}000\,d^3}{A\,P}$ may be used. In your case, valve area = 14.18 square inches, whence load on spring = 14.18 × 85 = 1,205.3 = $A\,P$.

$$D = \frac{8{,}000 \times (\tfrac{3}{4})^3}{1{,}205.3} = 2.8 \text{ inches.}$$

The outside diameter will be ¾ inch more than this. (*e*) The steam pressure tells us nothing, as you do not say how much surface the brace has to support. Neither do you say whether or not it is set at any angle, as when the boiler head is stayed to the shell. We shall simply assume that the rivets are to be such that there will be uniform strength throughout, that is, in them and the brace. Doing this, and further assuming the shearing strength of the rivets to be four-fifths of the tensile strength of the brace, we find that 1⅛-inch rivets, in single shear, would be required; that is, 1$\frac{1}{16}$-inch rivets in 1⅛-inch holes would do. This will allow only ¾ inch on each side of the rivet hole, however—not enough with this size of rivet and thickness of plate. If a wider brace cannot be used, make it thicker. (*f*) We presume you allude to the longitudinal stays. You say nothing as to size of boiler or thickness of plate. Assuming the latter to be steel and $\frac{7}{16}$ inch thick, and the stays fitted with nuts, you may use a pitch of 13½ inches. (*g*) We suppose you want to know how to find what length the connecting-rod requires to be. If both cylinder covers are on and screwed up, bump the piston up at each end alternately, and mark the position of crosshead on the guides. Deduct the required clearance at each end of stroke, and bisect the remaining length. Set the crosshead to this point. Then the piston is at half stroke. Take an adjustable train with one bent leg, and set to the center of crosshead pin and to the near face of shaft. Add half the diameter of shaft at this point, and the sum will be the length of rod required. If the shaft is not in place, stretch a line through the main bearings, and obtain the distance from the center line to the center of crosshead pin. If the measurement is taken from the face of the crosshead pin, add half of its diameter.

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(542) I enclose sketch of a steam separator, Fig. 1, showing the spiral around a cylinder. Kindly show how the layout of the spiral is made. Take, for

FIG. 1

example, a cylinder 12 inches in diameter, spiral belt 6 inches wide made of steel plate ¼ inch thick, and let the pitch be 12 inches.

H. M. L., Pottstown, Pa.

ANS.—The circumference of the cylinder being 12 × 3.1416 = 37.7 inches, the length of the helix for one turn around the cylinder is $\sqrt{37.7^2 + 12^2} = 39.563$ inches. This must be equal to the inner circumference of the annular plate, Fig. 2; hence, the inner diameter is 39.563 inches ÷ 3.1416 = 12.6 inches. In a similar manner, the outer diameter is found to be 18.4 inches. Since a screw surface is not developable, the plate must be hammered, or peened, when stretched along the cylinder. The stretch due to the hammering will be greatest at the outer edge, and will gradually diminish to nothing at the inner edge.

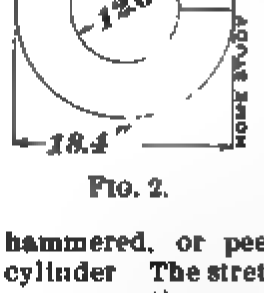

FIG. 2.

(543) (*a*) I wish to compress sufficient air to run a $\frac{1}{2}$-horsepower engine for one-half hour at a time. How large an air cylinder will be required? (*b*) What is the motive power generally used on horseless carriages? E. C. F., Rochester, N. Y.

ANS.—(*a*) We suppose you refer to the storage cylinder. If you compress to 500 pounds per square inch, a cylinder 20 inches inside diameter and 42 inches long will suffice. As you will use the air in the engine at a much lower pressure, say 80 pounds, you will require a reducing valve. If you compress to a lower pressure than the above, you will, of course, require more storage space, which may or may not be convenient to you. (*b*) Electricity, by means of storage batteries. A prominent firm in this country started in this work in August, 1895. The first carriage made was one run by electricity. They were about 18 months before putting it out publicly, and it was a success. At the same time they were working on a gasoline carriage, and this is not out yet. So far, builders certainly seem to have been more successful with the electric motor. A good many builders believe in steam. It is possible, however, that in the future compressed air will play a great part in this line of work. The same objection applies to that as to electricity: it is impossible to renew your power if away from the ordinary sources. This is why builders are trying to make a success of gasoline and steam, since the supply of oil, coal, and water may be renewed wherever one may be.

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(544) (*a*) Is there any rule for determining the size of air chamber on pumps working against pressure? (*b*) If there are any special points in the construction of air chambers, please give them. (*c*) Can you give a rule to find how much larger than the cylinder a piston ring should be turned, in order to give them the proper spring? What should be the width and thickness of rings? W. B. E., Downesville, Pa.

ANS.—(*a*) For double-acting single pumps, the air chamber should have a capacity three times that of the pump-piston displacement, that is, during one stroke. If for higher pressures and speeds, as in fire engines, make the capacity twice the above amount, that is, six times the displacement of one stroke of the piston. If the pump is a double-acting duplex, use a capacity from five to seven-tenths of the above. (*b*) Set the air chamber on the highest part of the pump, and, in every case, above the highest portion of the delivery opening. Keep the diameter of the neck as small as practical considerations allow. (*c*) It all depends on the section of the ring. The stiffer the ring, the less the difference need be between its original diameter and that of the cylinder. For an 18-inch piston, use two rings $\frac{11}{16}$ inch wide and $\frac{5}{8}$ inch thick. Turn to $18\frac{1}{4}$ inches in diameter and cut out $\frac{13}{16}$ inch of the ring. For 13-inch pistons turn rings $13\frac{3}{16}$ inches in diameter, and for 6-inch pistons turn them $6\frac{1}{8}$ inches in diameter; other sizes proportionately. See HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., August, 1897, article entitled "Piston Rings."

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(545) Kindly explain the principles of nickel-plating. Also give instructions for making a small plant for nickelplating and for giving the copper bath. G. S., St. Augustine, Fla.

ANS.—HOME STUDY FOR ELECTRICAL WORKERS, July, 1898, article entitled "Electroplating," will give you the required information with respect to the apparatus necessary for plating, and its manipulation. The copperplating bath may be prepared by taking 20 parts acetate of copper, which is made into a paste by addition of a little water; to this is added 20 parts carbonate of soda crystals dissolved in ten times as much water, the whole being well stirred. 20 parts bisulphite of soda is then dissolved in 200 parts of water and added, and subsequently 20 parts cyanide of potassium dissolved in 600 parts of water is added. If the bath is not clear, add more cyanide. The nickel bath is made in the proportion of 12 to 14 ounces double sulphate of nickel and ammonia to 1 gallon of water. To give a bright finish to nickel work, the objects must be buffed on a polishing lathe. A wire scratch brush is used for this, and may be obtained of any large dealer in electrical goods, together with all other materials necessary. Send for prices and particulars to Western Electrical Co., Bethune St., New York, N. Y.

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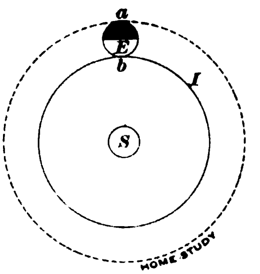
(546) (*a*) In the "Scientific American Supplement," for October 8th, 1898, there is an article by A. Lieberknecht, in which a new building material called "Papyristite" is mentioned. Can you tell me anything about this material, and of what firm in the United States it can be obtained? (*b*) We know that the top of the wheel of a running buggy goes faster than the bottom. In the accompanying diagram, *S* represents the sun, and *E* the earth; may not the earth be considered as a planet wheel running around the circumference of another wheel *I*, and does not the point *a* on the earth travel faster than the point *b*? Granting that this is so, the dark side of the earth must always be traveling faster than the light side; in other words, the surface of the earth travels faster during the night than during the day. May not this account for some of the magnetic and electric disturbances? J. L. H., Tallahassee, Fla.

ANS.—(*a*) We know of no firm in the United States dealing in "Papyristite," which is a new material. Write to "The Papyristite Company," at Poste Fach, 10,469, Zurich, Switzerland. (*b*) Your comparison is not quite correct. If the earth simply *rolled* along its orbit, the length of the latter would be about 6,100,000 miles, and its radius, or the distance from the earth to the sun, would be about 1,000,000 miles, instead of 93,000,000. The points farther from the sun move faster, not on account of their motion about the center of the earth, but on account of their motion of revolution about the sun. In this motion, the angular velocity of all the points is the same, but their lineal velocities are proportional to their distances from the sun. We do not know what effect this has on disturbances of any kind.



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(547) (*a*) Kindly publish a table giving the life of the telegraph pole when set in sand, in gravel, in clay, and in loam; include the following woods: cedar, tamarack, black poplar, white poplar, Pinus Banksiana, and spruce. (*b*) Is the life of a pole increased, if the surface for 2 feet below the ground and 6 inches above is painted with the following mixture: $\frac{3}{4}$ coal tar, $\frac{1}{4}$ pitch, and 1 pound of tallow added, all melted together in a pot and applied as hot as possible? (*c*) How many holes, 5 feet deep and 18 inches in diameter, ought one man to dig per day of 10 hours, in clay, in sand, in gravel, and in loam, using a spoon and digging bar? (*d*) What are the best pliers for telegraph work? H. G. H., N. W. T., Can.

ANS.—(*a*) The average life of poles under ordinary conditions may be placed as follows: Norway pine, 6 years; chestnut, 15 years; cypress, 12 years; cedar, 12 years; white oak, 6 years. The first four mentioned kinds of wood in this list are those most commonly used for telegraph and telephone poles in the

United States. We have no data concerning the other woods you refer to, and it would be almost impossible to compile a reliable table giving the life of each under the various conditions you mention. The life of a pole depends more on the climatic conditions than on the kind of soil in which it is embedded, and therefore a table which might be approximately correct for one portion of the country would be entirely incorrect for another. The kind of soil in which the pole is set does not figure in the life of the pole to such an extent as might be at first expected, for decay always sets in at what is termed the "wind-and-water line," that is, just at the surface of the ground. This is due to the fact that the alternate action of the air and water upon wood is much more destructive than the constant action of either one or the other alone. (*b*) The life of the pole would undoubtedly be increased if coated as you mention. Another good method is to apply hot pitch to the end of the pole for a distance of 6 feet from the butt. (*c*) It has been found that in average soil a man can dig eight 5-foot holes in 1 day of 10 hours, using preferably a 7-foot spoon shovel and an 8-foot digging bar. Of course, this figure does not apply where dynamite is to be used for blasting the holes. (*d*) Stubb's side-cutting pliers are probably the best for all-round telegraph work. A very fine grade of pliers is manufactured by Mathias Kline & Son, 85 W. Van Buren street, Chicago, Ill.

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(548) (*a*) Kindly explain how to make a dry battery of any desired shape or size. (*b*) Give me the name of a book on the subject of batteries in general.
E. L. C., Astoria, L. I.

ANS.—(*a*) See HOME STUDY MAGAZINE, August, 1897, Answers to Inquiries, No. 295. (*b*) Carhart's "Primary Batteries," price $1.50, The Technical Supply Co., Scranton, Pa.

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(549) (*a*) I have a small foot-power lathe, the headstock of which is fitted with a three-step cone pulley; the steps are 2 inches, 4 inches, and 6 inches in diameter. The largest step in the driving pulley is 28 inches in diameter. What should be the size of the other two steps on this pulley? (*b*) Do you know of any way in which a glass plate that is warped or bent can be straightened and made perfectly flat?
C. J. S., Jamestown, N. J.

ANS.—(*a*) You do not give the distance between centers nor the thickness of belt. Assuming these values as 30 inches and .2 inch, respectively, the two steps should be $25\frac{3}{4}$ inches and $27\frac{1}{4}$ inches, respectively. (*b*) Nothing but exposing the plate, resting on a flat surface in a furnace, to an even heat great enough to render it plastic will accomplish this.

***

(550) I want to heat a one-story building by hot water; the interior of the building is a single room 40 ft. × 60 ft. I don't know how to connect the pipes to the heater so as to obtain a proper circulation of the water. Please explain by means of a small diagram. C. H. B., New Richmond, Ohio.

ANS.—You do not tell us enough about your room, or your water heater, to enable us to give you any definite plan for running the pipes, or a sketch of the apparatus required. The following points, however, should help you: (1) Set your heater below the level of the radiators or coils with which you purpose to heat the room, and, if possible, locate it near the middle of the building. (2) Run a separate pipe direct from the top of the heater to feed each radiator with hot water. Pitch each pipe up towards its respective radiator, and arrange it so that air cannot collect and stop the circulation. (3) Run a separate pipe direct from each radiator, and connect it to the bottom of the boiler. This pipe is to convey water from the radiators back to the boiler, and must grade up towards the radiator to prevent air locks. (4) Place your radiators or coils against the outside walls and allow about 1 square foot of radiator surface for every 50 cubic feet of space in the room. (5) Place an air vent (a petcock will do) at the highest point of each radiator or coil, to let out air occasionally. (6) Attach an open expansion tank to the heater or to one of the pipes, care being taken to have no valve or stop-cock between the heater and this tank. The water-line in the tank should be at least 3 feet higher than the highest point of the highest radiator or any other part of the system. (7) Make your pipes equal in size to the radiator tappings; none should be smaller.

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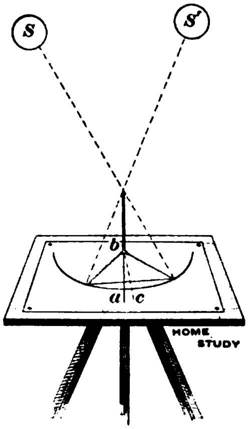
(551) (*a*) Describe the most correct way of establishing a meridian. (*b*) Show how the azimuth of Polaris for any latitude is ascertained. (*c*) Give me the name of some book that is considered an authority on the above subject, and contains the azimuths calculated for the different latitudes for each hour of the 24. C. M. G., Georgetown, Ohio.

ANS.—(*a*) There are several methods of establishing a meridian; such as by sun shadows, by equal altitudes of a star, by circumpolar stars, by Polaris, and by solar azimuth. The correctness of all three methods depends, to a great extent, upon the pains taken by the observer in his readings and operations. Consequently, the term "most correct" can be applied to none or all of them. A simple and ready method is the one by *equilinear shadows* on a sketch board mounted perfectly level on a wooden tripod, as shown in the figure. Having a roll of mapping paper tightened up on the board, draw the center line *ab* across the paper. Then place a rod or stile perpendicular to the table on some point of the center line, so that its shadow falls fairly well inside the edge of the paper.



About an hour or two before noon, when the sun is at *S*, place a mark with a pencil at the extremity of the shadow cast by the rod, and from the base of the rod as a center, and with a radius equal to the length of the shadow, describe an arc of a circle as shown. When the sun begins to drop again in the afternoon, watch the shadow until it once more touches the circle. Mark it, and bisect the chord drawn between the two shadow points, and draw a line *cb* to the base of the rod from the center of the chord. This line is the astronomical meridian. If the center line is drawn parallel to the magnetic north and south, as indicated by a compass, the angle *abc* is the variation of the compass at the place of observation. (*b*) The azimuth of Polaris, for any latitude when at elongation, can be computed by using the following formula:

$$\text{Sin azimuth} = \frac{\text{sin polar distance} \times R}{\text{sin colatitude}}.$$

R, expressed logarithmically, is equal to 10.000000. (*c*) "Land Surveying," by F. Hodgman, is a good book on this subject. We doubt the existence of any book containing the azimuth of Polaris for every hour of

the 24; such a table would be useless, since Polaris is visible only during the hours between sunset and sunrise.

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(552) The other day I found in a technical paper some remarks about three American steam engines, viz.: the Porter-Allen engine, the straight-line engine, by Mr. John Sweet, and the engine constructed and manufactured by the Lake Erie Engine Co. The engines were described without the aid of drawings, and in such a general manner that it was impossible for me to gain any useful information from the article. Can you publish drawings and an explanation of these engines? If this is asking too much, kindly tell me where I can obtain the information.

E. M., Erfurt, Germany.

ANS.—Lack of space prevents us from answering these questions. You will find the engines fully described in the catalogues of their makers. Write to the following firms, and ask them for a catalogue describing their engines: Southwark Foundry and Machine Co., Philadelphia, Pa.; Straight-Line Engine Co., Syracuse, N. Y.; Lake Erie Engineering Co., Buffalo, N. Y.

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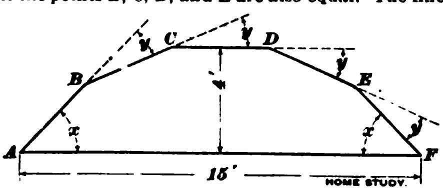
(553) In the enclosed figure, the sides AB, BC, CD, DE, and EF are all equal. The exterior angles at the points B, C, D, and E are also equal. The line



AF is parallel to CD. The dimensions are as shown. Find the length of AB, and the magnitude of the exterior angle at the point B.

J. R., Baker City, Ore.

ANS.—If l denotes the length of the line AB, we have

$$l(2\cos x + 2\cos y + 1) = 15. \qquad (1)$$

$$l(\sin x + \sin y) = 4. \qquad (2)$$

And $x = 2y$.

Dividing (1) by (2),

$$\frac{2\cos x + 2\cos y + 1}{\sin x + \sin y} = \frac{15}{4};$$

or,

$$\frac{2\cos 2y + 2\cos y + 1}{\sin 2y + \sin y} = \frac{15}{4}.$$

Whence,

$$1{,}156\sin^4 y - 995\sin^2 y + 120\sin y + 80 = 0.$$

Solving by Horner's method,

$$\sin y = .3957783.$$

Therefore, $y = 23^\circ\, 18'\, 52.3''$.

Therefore, $x = 46^\circ\, 37'\, 44.6''$.

From (2), $l = 3.481736$.

***

(554) I am a subscriber to HOME STUDY MAGAZINE, and read with great interest the articles on surveying. I cannot understand quite all that is given upon the subject of the retracing of lines in the article entitled "A Question in Land Surveying," appearing in the September, 1898, number. In the second paragraph on page 354, it is stated that, "Except in the north and west tiers of sections, a quarter-section corner would be relocated on the section line *midway* between the adjacent section corners." Now, suppose I am running north between sections *1* and *2*, and there is no quarter-section post to be found on the line between those sections, where must I relocate the corner? Should I place it midway between the corner of sections *1*, *2*, *11*, and *12* and the corner on the township line, or 40 chains of the original measure from the former corner? You will confer a great favor by explaining this point.

T. H. A., Cathlamet, Wash.

ANS.—As this quarter-section corner is on the line between two sections in the north tier of sections, it is one of the exceptions mentioned in the statement that you quote, and consequently, if the original corner is lost, it must be relocated in line between the section corners and at distances from them respectively proportional to the original distances as recorded; the corner will therefore be at a distance of 40 chains of the original measure from the corner of sections *1*, *2*, *11*, and *12*. If you will consult the notes of the original survey (of which you should by all means have a copy), you will find that this corner was established at a distance of 40 chains from the corner of sections *1*, *2*, *11*, and *12*, on the line run north from that corner, and that, whatever amount the distance from that corner to the closing corner on the township line (or true corner, if the line was corrected back) overran or fell short of 80 chains, the excess or deficiency was all thrown into the portion of the line between the quarter-section corner and the closing corner, usually rendering this distance fractional, that is, more or less than 40 chains. Knowing that the original position of the corner is its only true position, and bearing in mind the manner in which it was established in its original position, it is not difficult to understand the proper method of restoring it by measurement from the adjacent section corners, when all local evidences of its original position have become obliterated; for the conditions of the original survey must be reproduced as closely as possible. The line should be run and measured continuously from the corner of sections *1*, *2*, *11*, and *12* to the corner on the township line, setting a temporary stake on the measured line at 40 chains. After the entire line has been measured, this stake should be moved forward or back along the line, according as the new measurement overruns or falls short of the original measurement, to such position that the respective distances from the stake to the adjacent section corners will be exactly proportional to the corresponding recorded distances. For example, suppose that the distance from the corner of sections *1*, *2*, *11*, and *12* to the closing corner on the township line is recorded as 80.40 chains, but is found to measure 84.42 chains. As the quarter-section corner was originally established at a distance of 40 chains of the original measurement from the section corner, we have the proportion

$$80.40 : 84.42 :: 40 : x,$$

from which x, or the required distance, is equal to

$$\frac{84.42 \times 40}{80.40} = 42.00 \text{ chains},$$

which is the distance north from the corner of sections *1*, *2*, *11*, and *12* at which the quarter-section corner should be set. A corner should be restored by measurement, however, only when *all* local evidences of its original position have been obliterated.

***

(555) (*a*) Is there a book on machine engineering that contains full and complete descriptions and engravings of the type of marine steam engineering used on the Sound steamers and about New York Harbor? If so, kindly give me titles and prices of all the books you know of. (*b*) Does HOME STUDY MAGAZINE contain all the articles that are published in HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., HOME STUDY FOR THE BUILDING TRADES, and HOME STUDY FOR ELECTRICAL WORKERS?

F. E. D., Brooklyn, N. Y.

ANS.—(*a*) We know of no book on this special subject. We are told that either the London "Engineer" or "Engineering" is about to publish a series of articles on this subject, for which the paper has been collecting data for some time. We would advise you to watch these publications, which you will find on file in New York at the Cooper Institute, the Mercantile Library, the Astor Library, and at the rooms

of the American Society of Mechanical Engineers. (*b*) No. The three small publications are entirely independent of HOME STUDY MAGAZINE. Occasionally, however, an article that proves of very general interest is published in more than one of the publications.

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(556) (*a*) How many stakes can be driven into a space 15 feet square, no two stakes to be nearer together than 18 inches? (*b*) How many, allowing no two to be nearer than 15 inches?

A. C., Barretts Creek, Ky.

ANS.—(*a*) 121. (*b*) 169.

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(557) It is a well known fact that just before and during very wet weather, the barometer falls; as the weather improves and the air becomes drier, the barometer rises. Now, I have been having a discussion with a friend regarding this matter. I claim that a low barometer indicates light air, and that the finer the weather and the dryer the air, the heavier the atmosphere becomes. My friend claims that the reverse is true, and quotes the expression which most people use when, on a cloudy and damp day, they say that "the air is heavy." I say not, supporting my argument that, during wet and cloudy weather, the air is so light that the smoke escaping from chimneys falls instead of rising, as it does on a fine, dry day. He contends that, as the air contains more water when damp, it must be heavier, because the water displaces a certain amount of air, and is heavier than air. Kindly put us right in this matter.

W. D. M., Vancouver, B. C.

ANS.—A low barometer indicates low atmospheric pressure. When we say that the "air is heavy" we mean that the state of the atmosphere has a depressing effect upon us; at such times the barometer generally indicates *low* pressure. There is not space in these columns for an explanation of the subject. In an early number of HOME STUDY MAGAZINE, however, an article will appear, in which the whole matter will be very thoroughly explained.

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(558) I enclose an illustration of the "National" transformer. Kindly explain how this apparatus is constructed, and how to connect the arc-lighting system. If you are not familiar with this transformer, any other type will do.

G. P., Minneapolis, Minn.

ANS.—The transformer that you mention is annular in form, the primary and the secondary coils being wound over a ring made of soft sheet iron. The terminals of the primary winding are *a*, *b*, and the terminals of the secondary are *c*, *d*. The outside line wires are connected at the primary terminals, and, from the heavier wires of the secondary winding, connection is made to the lighting circuit in the house.

***

(559) (*a*) Kindly tell me why the regulator in the Thomson-Houston arc machine will not work without the wall controller. What does the controller do, and what is the principle upon which it works? (*b*) Give me the name of some good book on ice making and refrigerating machinery.

W. H. C., Oil City, Pa.

ANS.—(*a*) If the regulating magnet alone were used, the current would pass around it continuously, and no changing effect would be available to move the brushes. The wall controller determines automatically when it is necessary to draw up the lever connected to the brushes. If the current falls below the normal amount, the cores of the controlling magnet descend and complete the circuit through the coils of the regulating magnet, which then moves the brushes in such a way as to increase the current strength. As soon as the current is again at the proper strength, the controlling magnet opens the circuit of the regulating magnet. (*b*) Stephansky's "The Practical Running of an Ice and Refrigerating Plant," price, $2.00. This book may be had of The Technical Supply Co., Scranton, Pa.

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(560) (*a*) I wish to construct an acetylene-gas lamp. What is the most suitable metal for the body of the lamp—a metal that will not rust or corrode? (*b*) In HOME STUDY MAGAZINE, September, 1898, Answers to Inquiries, No. 360, a book entitled "The Pattern-Maker's Assistant" is mentioned. What is the price of this book? Is it illustrated, and does it treat on patterns for machinery?

H. B. S., Rochester, N. Y.

ANS.—(*a*) There seems to be quite a difference of opinion in this matter. Some authorities state that copper, brass, aluminum, and iron are all perfectly safe metals, while others strongly and emphatically condemn the use of copper or brass. The inspector of explosives for Great Britain, after a series of rigid tests and investigations relating to the properties of acetylene gas, prepared for the English Home Office an exhaustive report, in which he states that "acetylene gas is capable of forming an explosive compound when brought in contact with copper." It would appear, however, from the large number of acetylene lamps now on the market, that nickel-plated brass is the favorite metal. (*b*) "The Pattern-Maker's Assistant," by Rose, treats on all branches of the subject of patternmaking; patterns for machinery, being the most important of these branches, receives more attention than any of the others. The price of the book is $2.50, and it may be obtained from The Technical Supply Co., Scranton, Pa.

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(561) (*a*) Please give formula for finding the stress in a rectangular plate when supported and restrained on all sides? (*b*) Give formula for a square plate under similar conditions. If possible, show how the formulas are obtained.

J. P. E., Brooklyn, N. Y.

ANS.—(*a* and *b*) No one has as yet derived formulas for the stress in plates under these conditions, the mathematical analysis being so difficult as to allow of no approximations that would have any practical value.

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(562) Is it true, in the case of a locomotive with ordinary link motion, that the cut-off—if it has not been equalized by offsetting the saddle pin—will occur earlier on the crank end when the valve motion is direct, and earlier on the front end when a rocker is used? As the motion of the main rod remains the same, I cannot conceive how the rocker (the eccentrics being of course shifted to correspond) can affect the cut-off in this manner, that is, transfer the early cut-off from the crank end to the front end.

H. T. B., Milwaukee, Wis.

ANS.—There are three sources of error in the matter of unequal cut-off in locomotives. First consider a case where no rocker is used. The errors are as follows: (1) The effect of the main rod causes a late cut-off at the front end, and an early cut-off at the back end. (2) The effect of eccentric rods produces irregularity precisely similar to those produced by the main rod. (3) Offsetting the eccentric-rod pins back of link arc also produces late cut-off at front end and early cut-off at back end. Now, this last error being of the same nature as (1) and (2), the joint effect is to produce a late cut-off at front and an early one at back. If we introduce a rocker,

we do not affect motions (1) and (2), but we exactly reverse that of (3). For, suppose the crankpin to be on the top quarter in the fore gear; then, if there is no rocker, the cut-off is early at the back end. Now, imagine a rocker put in, and swing the crank to the bottom quarter, still keeping the engine in fore gear, and the eccentrics remaining in the same position. Then, since the link block was previously too near the back end (cutting off early), the interposition of a rocker throws the valve too near the front end, and so cuts off early *there*, the crank this time moving towards the firebox, instead of towards the cylinder, as in the previous case. Similarly for other crank positions. So that using a rocker *does* change the early cut-off from the back end to the front. How this is remedied is explained in HOME STUDY MAGAZINE, November, 1898, Answers to Inquiries, No. 463. The reason why the location of the eccentric-rod pins affects the cut-off is that the line passing through eccentric center, eccentric pin, and link arc is not a straight line, but a bent one. (It is understood that the line from eccentric pin to link arc is taken normal to the latter.) The valve is thus always nearer to the back end than would be the case if the eccentric pins were on the link arc, and, when rocker is used, it is nearer to the front end, thus cutting off early at this end.

***

(563) If an ordinary mercury barometer were placed on the top of Mt. Everest, what would be the length of the mercury column?

V. A. B., Austin, Ill.

ANS.—The height of Mt. Everest is given by some authorities as 29,002 feet. The meteorologist Glaisher made a balloon ascension July 17, 1862, reaching the great height of 37,000 feet. He recorded the barometric reading at 29,000 feet as 9¾ inches; and at 37,000 feet as 7 inches.

***

(564) (*a*) In as simple a manner as possible, prove that, in the triangle ACB, $AC : AB :: \sin B : \sin C$. (*b*) Why are different signs, viz., plus and minus, given to trigonometric functions in the different quadrants? As the *value* does not change, I fail to see the use of the sign.

E. J. S., Camden, N. J.

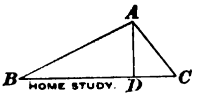
ANS.—(*a*) Draw the line AD perpendicular to BC.

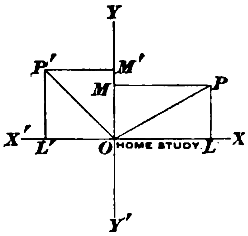
Then, $\sin B = \frac{DA}{AB}$, and $\sin C = \frac{DA}{AC}$.

Therefore, $$\frac{DA}{AB} \div \frac{DA}{AC} = \frac{\sin B}{\sin C}$$

or, $$\frac{AC}{AB} = \frac{\sin B}{\sin C}.$$

Therefore, $AC : AB = \sin B : \sin C$. (*b*) Let $X'X$ and $Y'Y$ be two lines intersecting at right angles in the





point O. If it is required to measure a given length along the line $X'X$, starting from the point O, the question arises whether the given length is to be measured toward the right or toward the left. In order to avoid this difficulty, mathematicians agree to consider lines measured along $X'X$ toward the right as positive, and consequently lines measured toward the left must be regarded as negative. In like manner, distances measured upwards along $Y'Y$ are taken as positive, and those measured downwards along $Y'Y$ are taken as negative. If OP is any line through O, and if PL and PM are drawn respectively perpendicular to $X'X$ and $Y'Y$, the line OL is called the *projection* of OP on $X'X$, and the line OM is called the *projection* of OP on $Y'Y$. Now, the ratio of the projection of OP on $Y'Y$ to the line OP is called the *sine of the angle* XOP, and is denoted by $\sin XOP$. The ratio of the projection of OP on $X'X$ to the line OP is called the *cosine of the angle* XOP, and is denoted by $\cos XOP$. That is,

$$\sin XOP = \frac{OM}{OP};$$

$$\cos XOP = \frac{OL}{OP}.$$

Applying these definitions to the angle XOP', which is 135°, we have

$$\sin XOP' = \sin 135° = \frac{OM'}{OP} = \frac{1}{\sqrt{2}};$$

$$\cos XOP' = \cos 135° = \frac{OL'}{OP} = \frac{-1}{\sqrt{2}}.$$

Thus, cos 135° is negative, because OL', being measured toward the left, is negative. We advise you to procure a copy of HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., July, 1898. In this number there is an article entitled "Positive and Negative Quantities," which will help you.

***

(565) (*a*) Please explain how to connect up an ammeter on one or two lines. Are they connected to the main feed wires? (*b*) How is a voltmeter cut in? (*c*) Should the rheostat be on the same line as the voltmeter? (*d*) How are ground lights installed so as to burn brightly when there is a ground on, or dimly when lines are clear? (*e*) How can the north pole of a dynamo be distinguished from the south pole?

X. Y. Z.

ANS.—(*a*) An ammeter, if mounted on a switchboard, should be left permanently on one circuit. If only one is to be used, connect it in the main circuit, between the main switch and the bus-bars. If a separate circuit is to be indicated, put an ammeter in that circuit. (*b* and *c*) See HOME STUDY MAGAZINE, November, 1897, Answers to Inquiries, No. 459. (*d*) See HOME STUDY MAGAZINE, December, 1898, Answers to Inquiries, No. 512. (*e*) See HOME STUDY MAGAZINE, November, 1897, Answers to Inquiries, No. 471.

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(566) I am running an ammonia compressor connected directly with a Corliss steam engine. It consists of two single-acting vertical cylinders 9 inches in diameter, 16-inch stroke; receiver pressure, 100 pounds gauge; back (suction) pressure, 25 pounds gauge. The Corliss cylinder is 12 inches in diameter, 30-inch stroke, horizontal; steam pressure, 90 pounds gauge revolutions per minute, 65. The cranks are set at 180 degrees and the connecting-rod of the engine and that of one of the compressors work on the same pin; the flywheel is 8 feet in diameter. The compressor runs in jerks, and I claim that the flywheel is too light. Kindly inform me (*a*) how heavy should the flywheel be under the above conditions; (*b*) if we should conclude to disconnect the engine, and run the compressor with a belt from the countershaft, would it be necessary to put in a heavier belt pulley? If so, what should the weight be, the diameter being 8 feet, and the running conditions the same as with the steam engine? (*c*) If we decide to make a change in the speed of the compressor, would a corresponding change in the weight of the belt pulley be necessary? In answering the above give the formulas used. (*d*) Can you give me the names and prices of books on this subject?

J. M. S., San Francisco, Cal.

ANS.—(*a*, *b*, and *c*) A complete answer to your questions would require much more space than can be spared here. In your plant the fault is that the compressors are single-acting; merely changing the crank angles is not a remedy. As the engine now stands, the variation of resistance is considerable; for instance, when passing the top quarter, where the rotative effort is at a maximum, at the moment

the quarter is reached, one of the pumps A is discharging into the receiver, and the plunger therefore has the maximum pressure opposed to it. The other plunger B is at the other end of stroke, just finishing its suction, and preparing to compress. Directly the crank passes the quarter, the plunger A not only ceases to oppose the crank's motion, but actually helps it, owing to the expansion of the air (at 100 pounds pressure) in the clearance spaces. At the same time, the plunger B is only just beginning its compression stroke, and therefore offers but little resistance to the engine. There is thus a very great and sudden variation of pressure, which, considering the slow rotative speed, can only be ameliorated by a heavy flywheel of large diameter. One weighing 10,000 pounds would be of advantage; use as large a diameter as practicable, within reason; there is no fear of bursting, at the speed this engine runs. (*d*) "Compressed Air," by Richards, price $1.50, will perhaps give you some information in the direction you require. Why not write to the people who supplied the plant?

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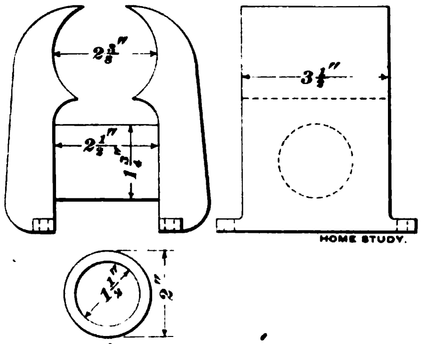
(567) The enclosed sketch gives you the dimensions of the "Improved Bipolar Motor," which I wish to rewind for a 110-volt circuit. What would be the correct size of wire, and number of turns per coil, and number of coils for the armature? Also, what would be the size of the wire and number of turns for the field? F. P. C., Irvington, Ind.

ANS.—Make an armature core of the dimensions shown at *A*, and make a Gramme ring winding of



A

about 4,000 turns of No. 31 B. & S. single cotton-covered magnet wire. Use a $\frac{3}{4}$-inch shaft, and support the core by spiders at each end, but without a hub, extending into the core. Wind the field with as much No. 31 single cotton-covered wire as you can get on. This computation, it should be noted, is for a shunt winding.

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(568) (*a*) Which is preferable for mixing with cement for concrete work—clean, fine, river sand, or tailings from the stamp mill? (*b*) What is the freezing point of alcohol? W. P. C., New Castle, Cal.

ANS.—(*a*) Clean river sand—not too fine. (*b*) About —100° C., or —148° F.

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(569) (*a*) Kindly give me the names and prices of books dealing in an elementary manner on iron working. (*b*) Also, name book on bridge construction dealing especially with cylinder work.
W. A. J., Hunterville, N. Z.

ANS.—(*a*) The term "iron working" is very indefinite, being applied to every branch of the art of working iron, from the smelting of the ores to the operations of the smith, the foundryman, and the bridge builder. We will assume, however, that the general operations of smelting, refining, and the operations involved in the rolling mill and forge are referred to in the question, in which case the following books will be found good: "Treatise on the Metallurgy of Iron," by H. Bauerman, price $2.00; "Metallurgy of Iron and Steel," by Thomas Turner, price $5.00. (*b*) A book entitled "Cylinder Bridge Piers," by John Newman, price $2.50, treats of this subject quite fully. The above books may be obtained from The Technical Supply Co., Scranton, Pa.

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(570) Given, an ordinary bucket, circular in shape. If I fill this with water to the point of overflowing, empty into a larger vessel, then pinch in the top of the bucket so that, instead of being circular, it is elliptical in shape, I find, on pouring the water back into it, that it will not hold it all. I cannot understand this. It hardly seems to me that changing the shape in the way mentioned will decrease the capacity. It certainly does so, however. Can you explain it? I. S., Osnaburg, Ohio.

ANS.—The area of a circle is greater than the area of any other figure whose perimeter is equal to the circumference of the circle. Hence, when the bucket is distorted from its circular shape, the area of each cross-section is diminished, while the height of the bucket is not increased; therefore, distorting the bucket diminishes its volume.

***

(571) Can you tell me the composition of the metal that is used in the manufacture of gongs? I have been told that these are made exclusively in China, but I think it more than probable that some are made in this country. If you cannot give me this information, can you refer me to any American manufacturer who is likely to know the formula used in China?
A. J. H., New York, N. Y.

ANS.—As far as we can ascertain, the alloy consists of 78 to 80 parts of copper and 22 to 20 of tin. This is hammered out to shape, being annealed at intervals during the operation. We do not know of any American manufacturer of these gongs.

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(572) One panel of a Pratt truss highway bridge is 15 feet long, 16 feet wide and 20 feet high; the bridge floor is laid transversely, and is of 3″ × 10″ pine. Provision is to be made for a concentrated load of 10,000 pounds, on two axles 6 feet apart. Maximum fiber stress, 1,200 pounds per square inch. The live load per square foot of floor area is 100 pounds. Assuming the joists to be of pine, what is the proper distance between their centers?
J. H. R. S., Berkeley, Cal.

ANS.—If we assume, as an extreme condition, that one-fourth of the concentrated load (2,500 pounds) is supported upon each of four wheels having a narrow tread, and that a wheel is in position midway between two joists and supported wholly by one floor plank, then, by substituting these values and the dimensions of a floor plank in the formula

$$\frac{W l}{4} = \frac{S b d^2}{6},$$

in which
W = center load;
l = span;
S = fiber stress;
b = width of the plank;
d = depth of plank;

we get
$$\frac{2{,}500\, l}{4} = \frac{1{,}200 \times 10 \times 9}{6},$$

from which $l = 28.8$ inches, which is thus the extreme distance between centers of joists over which the floor planks can carry the load under the assumed conditions, when their strength is not diminished by wear or decay. A distance of 24 inches between centers of joists is commonly adopted for highway bridges, and this distance will not be too great in the present case, so far as the strength of the floor planks is concerned, even after considerable deterioration,

as the treads of the wheels supporting the concentrated load will probably be of sufficient width to somewhat distribute the load. In order to ascertain the dimensions required for the joists, we shall assume the load on one front and one rear wheel to be supported entirely by two joists, the load being in such a position as to produce the maximum bending moment. The maximum bending moment M, produced by two equal loads moving across a span, is given by the formula

$$M = \frac{W}{l}\left(\frac{l}{2} - \frac{m}{4}\right)^2,$$

in which l = span in feet;
W = total weight of the two loads;
m = distance between the two loads.

By assuming a depth for the joists, and writing the moment of resistance equal to the bending moment, substituting the proper values, we can ascertain the aggregate width of the two joists required to resist the bending moment due to the load. Thus, assuming a depth of 12 inches for the joists, we have

$$\frac{5{,}000 \times (7.5 - 1.5)^2}{15} \times 12 = \frac{1{,}200 \times b \times 12^2}{6},$$

from which $b = 5$ inches. A size of 3 in. × 12 in. for each joist will, therefore, fulfil the requirements of the assumed conditions, and, as the effect of the uniform load is less than that of the concentrated load, and both loads cannot be upon the same joists at the same time, this size will fulfil all requirements. A fiber stress of 1,200 pounds is permissible for long-leaf yellow pine, but is too high for white pine.

* * *

(573) I have a steam cylinder 26 inches in diameter, 1¾ inches thick for a 48-inch stroke. The cylinder head is secured with sixteen 1¼-inch bolts; thickness of flange is 1¾ inches. What is the safe working pressure for this cylinder, and how is it determined? E. M. A., Akron, Ohio.

ANS.—Practice varies in the matter of thickness of cylinder walls, the relation between bursting pressure and external pressures being not well understood. Recourse is therefore had to empirical formulas.

When t = thickness of wall in inches;
P = greatest steam pressure per square inch;
D = diameter of bore in inches;

then (after Seaton), $t = \frac{P\,D + 500}{2{,}000}$;

(after Haswell), $t = \frac{P\,D}{2{,}000} + \frac{1}{8}$;

(after Whitham), $t = .03\sqrt{P\,D}$.

These three formulas would then give for working pressure in your case, respectively,

P = 115.4 pounds per square inch.
P = 125 pounds per square inch.
P = 130.7 pounds per square inch.

The average of these is 123.7 pounds.

* * *

(574) (*a*) With a pressure of 60 pounds at the plug, to what height will a stream of water be thrown after passing through 200 feet of hose, discharging through a regulation 1¼-inch nozzle? (*b*) With a pressure of 100 pounds, what will the height be? (*c*) If 500 feet of hose were used, to what height would the water rise under each of the above conditions? C. P. C., Springfield, Mo.

ANS.—(*a*) The frictional losses in the hose, and, consequently, the height to which the water will rise, varies with the diameter of the hose and its condition—factors that you have not stated. Assuming, however, that a standard 2½-inch smooth rubber-lined hose is used, experiments indicate that the height would be about 60 feet. (*b*) With the same assumptions as in the answer to (*a*), the height would be about 90 feet. (*c*) About 30 and 55 feet, respectively.

* * *

(575) What are the formulas used in calculating the strength of an electromagnet? Take, for example, a magnet that is required to lift a load of 100 pounds through a quarter-inch air space; volts, 220. What relation does the pull of the magnet bear to the distance from the load to be lifted? C. J. S., Philadelphia, Pa.

ANS.—See HOME STUDY MAGAZINE, November, 1897, article entitled "The Design of Hoisting Magnets."

* * *

(576) Please suggest an idea for mechanically picking up and tying together in a knot two ends of light twine. G. P. V. S., Cincinnati, Ohio.

ANS.—We infer that by "mechanically" you mean "by machinery." We have no information regarding a machine for this purpose, and we do not make original suggestions of such a nature in these columns. Consult an expert mechanical engineer.

* * *

(577) (*a*) Does it do any harm if the core of an induction coil is allowed to become rusted? (*b*) Will a layer of beeswax and rosin mixture $\frac{1}{16}$ inch thick be sufficient to guard against rupture from a ¾-inch spark? T. G. S.

ANS.—(*a*) The effect of rust on the core is to reduce its cross-sectional area, and in the case of a core made of small wires this may cause a marked effect. (*b*) Yes; if there is $\frac{1}{16}$ of an inch of the insulator at all points.

* * *

(578) (*a*) What is Thoulet's solution? From what I know, it must be a heavy liquid of some kind. (*b*) I wish to procure, at a comparatively low cost, a liquid whose specific gravity is about 3—not less and preferably more; a liquid that is not soluble in water, if possible. (*c*) Is there any oil or fat that has a boiling point as high as 500° F.? Will you please publish a table giving the boiling points of various heavy oils and paraffins? (*d*) Has any process ever been patented for recovering fine placer gold, by forcing the gravel or sand containing it through mercury, allowing the gravel to rise and be washed off, and the gold to be amalgamated? If this method has been tried and found wanting, explain how it failed. M. J. S., Mullan, Idaho.

ANS.—(*a*) We never heard of "Thoulet's solution," and cannot find any reference to it in any book on chemistry at our command. (*b*) Use mercury, which is insoluble in water and has a specific gravity of 13.59. (*c*) Hexadecane ($C_{16}H_{34}$) boils at 548.6° F. The boiling points of a number of members of the paraffin series are given below:

Pentane	(C_5H_{12})	96.8° F.
Hexane	(C_6H_{14})	156.2° F.
Heptane	(C_7H_{16})	208.4° F.
Octane	(C_8H_{18})	257.0° F.
Nonane	(C_9H_{20})	300.2° F.
Decane	($C_{10}H_{22}$)	343.4° F.
Dodecane	($C_{12}H_{26}$)	417.2° F.
Hexadecane	($C_{16}H_{34}$)	548.6° F.

(*d*) We do not know of any such process having been patented. For such information we will refer you to the records of the U. S. Patent Office. We know, however, that this method of gold recovery is not used in placer mining. It would be impracticable for many reasons, the most important of which are as follows: Large quantities of mercury would be required and much capital would be constantly locked up in the amalgam. It would be quite difficult to pass through the mercury, and completely submerge, the large amounts of gravel it would be necessary to handle. Trouble would be encountered in washing the gravel clean of mercury and fine amalgam and also in separating the mercury from the amalgam—the quantity of mercury being

so large. The losses of gold, amalgam, and mercury would be large. Mercury wells—which consist of shallow troughs or gutters filled with mercury—are often used in connection with amalgamated copper plates in stamp batteries, and with riffles in sluices for saving fine gold and amalgam. The tailings, gravel, pulp, etc. pass through the wells, generally over the surface of the mercury, but in some cases through the mercury—which is an application, on a small scale, of the above mentioned process. Various devices—such as vertical iron partitions dipping beneath the surface of the mercury, and paddle wheels—are employed to submerge the material.

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(579) (*a*) Please explain how to calculate the currents in the circuits shown in (*a*) and (*b*), Fig. 1. (*b*) Kindly explain how dynamo *B*, shown in Figs. 2 and 3, acts to equalize the system when the circuits on either side of the neutral wire are out of balance. (*c*) How is the power calculated for a delta-connected and for a star-connected generator or motor, for a two-phase or a three-phase system?

J. C., Covington, Ky.

ANS.—(*a*) The batteries in (*a*), Fig. 1, are working in opposition to each other, while in (*b*) they act in

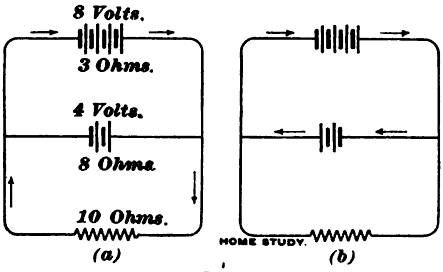

FIG. 1.

unison. The E. M. F. of the large battery is 8 volts, and of the small battery, 4 volts; the respective resistances of the three circuits are designated r, r_1, and R, and it is required to find the current strength C, c_1, and c_2 in the three branches. We have, then, three unknown quantities C, c_1, c_2, and need the same number of equations to find their values. For circuit (*a*) the following equations will apply:

$$C = c_1 + c_2;$$
$$Cr + c_2 R = E;$$
$$c_2 R - c_1 r_1 = E_1.$$

Inserting the known values of r, r_1, R, E, and E_1, we find,

$$c_1 = .209 \text{ ampere.}$$
$$c_2 = .5672 \text{ ampere.}$$
$$C = .7762 \text{ ampere.}$$

For circuit (*b*) the first two equations are the same, but the third is different and is as follows:

$$c_2 R - c_1 r_1 = -E_1.$$

Again inserting the known values, we have

$$c_1 = .985 \text{ ampere.}$$
$$c_2 = .388 \text{ ampere.}$$
$$C = 1.373 \text{ amperes.}$$

(*b*) In Fig. 2 the arrangement indicated consists of two generators *A* and *B*; the generator *A* has double the potential of all the receivers whether lamps or motors, while the dynamo *B* is capable of developing an electrical pressure equal to that required by a single receiver. Of course, if a 220-volt motor is used the system will not be unbalanced, so we may assume that the total load is composed of 100-volt incandescent lamps. Let the voltage of dynamo *A* be 220 volts, and that of dynamo *B* equal 110 volts. Both machines are connected to a common source of power, or prime mover *p*. When the load on the positive side of the system is greater than that on the negative side, as indicated by the greater number of lamps burning (the lamps that are burning are indicated by light circles, and those extinguished, by heavy

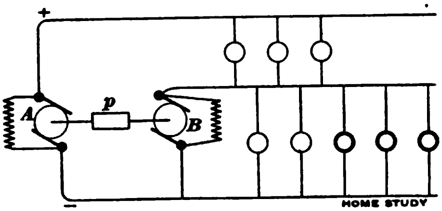

FIG. 2.

circles) on the positive side, a current returning through the central conductor actuates the dynamo *B*, causing it to operate as a motor, thus relieving the prime mover *p* of a part of the load of the dynamo *A*. When, on the contrary, the negative side of the system is the more heavily loaded of the two, made so by turning on the remaining lamps, the dynamo *B* acts as a generator, supplying the necessary additional current. The design of Fig. 3 involves the use of compensators, the outline of the connections being shown. These compensators are two shunt-wound dynamos, the fields being placed across the outer mains, as shown at *f* and *g*. The armatures of the two compensators are wound upon the same shaft, in order to rotate exactly in unison. When the two outer conductors of the line are equally loaded, a very small current flows through the compensators, simply sufficient to turn the armatures, overcoming the frictional resistance. As soon as the system becomes unbalanced, the armature connected with the main carrying the least current becomes a motor, while the other armature plays the part of a dynamo, the balance of the system being restored; for one of the compensators, acting as a motor, drives the other armature as a generator furnishing the excess current required upon the overloaded main. Compensators of this sort, combined on the same shaft, are known

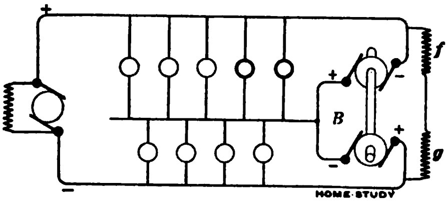

FIG. 3.

as a single piece of apparatus and called a motor generator. (*c*) In any polyphase system the total amount of power is equal to the arithmetical sum of the power in each phase. The power for each phase can be found by means of the following formula:

$$W = E_e C_e \cos \theta,$$

where W = watts;
E_e = effective voltage;
C_e = effective current strength;
$\cos \theta$ = cosine of angle of lag between current and E. M. F. (This factor numerically equals the power factor.)

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(580) Kindly explain how steel can be tinned so as not to blister. W. H. F., Louisville, Ky.

ANS.—Cleanse the article thoroughly in dilute sulphuric acid. We do not know of any special trade process involved.

(581) Kindly give me (*a*) a rule for calculating the diameter of sheaves or drums; (*b*) the diameter of wire cable for hoisting a given load.
J. A. B., Philadelphia, Pa.

ANS.—(*a*) The diameter of a drum upon which a rope carrying a load is wound, or the diameter of a sheave that deflects such a rope from a straight line, affects to a large degree the life of the rope. The rule in common practice is to make the diameter of the drum or sheave 60 times the diameter of the rope, when using the more pliable ropes made of 19 wires to the strand; or 100 times the diameter of a rope containing 7 wires to the strand. (*b*) A reliable formula for calculating the diameter (d) in inches of an iron-wire rope that will handle a safe load (W) in pounds is as follows: $d = .0132\sqrt{W}$; for cast steel $d = .0093\sqrt{W}$, and for plough steel $d = .0077\sqrt{W}$.

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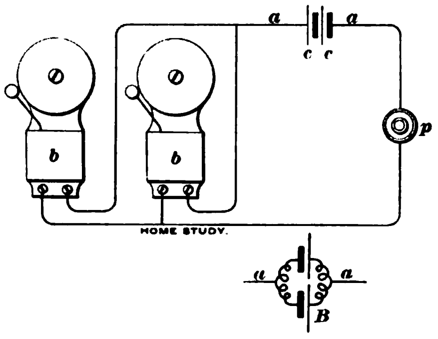
(582) (*a*) What is the most suitable battery for operating 3 or 4 door bells or alarm bells? (*b*) What is the best way to connect up the wires in order that the bells may be effective at all times? (*c*) What is the best way to operate a private electric-light plant, having a total of 25 lights? (*d*) Is a windmill suitable for charging a storage battery? (*e*) Is there such a thing as a self-generating electric cell, to which power could be supplied by means of a dynamo?
N. A. B., Denver, Col.

ANS.—(*a*) You will get the most satisfactory service from a carbon cylinder sal ammoniac battery, the number of cells depending upon the conditions under which they have to operate. (*b*) Connect each circuit to the battery independently of the rest, provided that independent circuits are required. If all three or four bells are to ring at one time and on one



circuit, connect them in multiple, as shown in the sketch. (*c* and *d*) With power from a windmill available, the best plan would be to purchase a dynamo of about 1½ K. W. or 2 H. P. rating, and a storage battery of a normal discharge rate of 15 amperes, and of about 300 ampere-hour capacity. The number of cells should be apportioned according to the voltage of the dynamo, allowing 1.7 volts per cell. See HOME STUDY MAGAZINE, March, 1898, article entitled "Electricity from Wind-Power." (*e*) No.

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(583) I have a 15-light dynamo, Edison type, giving 52 volts. I have connected it in series, and have also put a battery in circuit with the fields; but it will not work in that way, although it will operate all right as a shunt machine. Will you kindly give me instructions for connecting the dynamo as a series machine?
J. C. F., Knoxville, Tenn.

ANS.—The battery which you should use ought to give an E. M. F. of 52 volts, and should be of such a type as to maintain a constant rate of discharge, such as is obtained from a storage battery. With the field connected in this way, you would have a separately excited machine, as the field would then have no connection with the armature. Your dynamo, having been designed as a shunt machine, will not give very much satisfaction when connected in series. The following directions should be observed in connecting it in series: Carry one field terminal to one of the brushes, and connect the remaining field terminal to one main. The other main should be connected to the remaining brush.

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(584) (*a*) What compound, or simple chemical, will remove rust from steel without injuring the metal? (*b*) Is the Edison tasimeter considered more sensitive to heat waves than the thermopile and galvanometer? (*c*) What chemical, or chemical compound, is used to soften water? (*d*) Is the substance injurious to the skin, if used when washing? (*e*) Kindly publish a short description of a selenium cell, that may be employed for detecting small variations in the intensity of light. (*f*) Why cannot we telephone across the ocean?
E. L. O., New York, N. Y.

ANS.—(*a*) The following is recommended, but we cannot say from personal experience just how well it fulfils its purpose: Cover the article with sweet oil well rubbed in and allow it to stand for 48 hours. Polish with unslaked lime. (*b*) The Edison tasimeter is not credited with being as sensitive as the thermopile as a means of measuring radiated heat. It may be said, on the other hand, that it has never been handled in the same systematic manner by experts at such work. In its present form, however, it is very far from being equal to the thermopile, or the bolometer. (*c*) Add a little common washing soda and boil the water. (*d*) No. (*e*) Wind two separate spirals of platinized silver wires around a cylinder of hard wood, taking care to maintain a constant distance between them, so as to avoid their contact. The space between these wires is filled with fused selenium, which is allowed to cool gradually; exposure to sunlight reduces its resistance to about one-half its resistance in the dark, but neither the resistance nor the reduction ratio remains long constant. However, for your purpose this arrangement will suit the conditions admirably. (*f*) A cable running under the ocean possesses immense capacity as a condenser, and practically no self-induction. The action of each of these phenomena is to neutralize the other, so it is evident that where one, only, is present, as in the case of a submarine cable where capacity alone exists, the effect is to subject the circuit to the conditions due to the presence of either manifestation. The effect of the capacity of the cable is to utilize, or rather waste, all the current in charging and discharging it. It has been suggested to connect, in the circuit, coils possessing high self-induction, for the latter will neutralize, or tend to neutralize, capacity in a circuit when connected in series with the apparatus possessing the capacity. It would be possible, by the use of this scheme, to make the cable available only for currents of one frequency, and as the transmission of speech, sound, and noise depends on the variation in the frequency of the current, it is evident that the problem is still unsolved.

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(585) In what manner can the percentage of carbon of oxygen and of refuse matter in a given sample of coal be determined?
H. A. F., Mont Alto, Pa.

ANS.—The answer to this question involves a discussion of analytical chemistry, which would be long for these columns and would probably be of no value to the inquirer.

MAN'S NOBLEST AIM.

WRITTEN in the splendor of sunlight; graven in the mellowness of moonlight; emblazoned on the azure sky by the marvels of heavenly systems, every star a character, and every constellation a sentence; unfolded on every wave of the unfathomable and ever changeful ocean; inscribed upon every verdant field and golden harvest; traced upon every flower and leaf; whispered by every breeze that sways the undulating prairie, or makes the mighty forest vocal; emphasized by mountain peak and snow-capped sierra; thundered by roaring cataract; murmured by babbling brooklet; mirrored in lake and lakelet, is Heaven's warmest, never ceasing invitation: "O Son of Man, study—all Nature, God's own book, is before thee: take up and read: its every lesson will gladden thy heart and strengthen thy soul."

Study is the covenant between man and immortality, the bond between the present and the hereafter, the link between time and eternity. It becomes the sceptered king better than jeweled crown, the armored soldier better than gilded panoply.

Hence Shakespeare says:

Alas, how should you govern any kingdom,
That know not . . . how to *study* for the people's welfare.

Bradley, in his story of the Goths, tells us that, "it was the King Theodoric's special *study* so to apportion the taxes that the burden fell as equally as possible."

It is the statesman's inspiration, the warrior's security, the hope of the toiler, the incentive of the tried and the tempted.

If a man have great talents study will improve them; if he have but moderate abilities, study will make up their deficiency.

The sons of men study makes like unto the up-growing cedars of Libanus, and the daughters thereof like unto the polished corners of the temple. It is that God-sent heaven-blessed spirit which to eager and ambitious youth conveys the message from above:

Be not content. Contentment means inaction,
The growing soul aches on its upward quest.
Satiety is twin to satisfaction:
All great achievements spring from life's unrest.

* * * * * * *

Were man contented with his lot forever,
He had not sought strange seas with sails unfurled,
And the vast wonder of our shores had never
Dawned on the gaze of an admiring world.

Through study, the student recognizes the poverty of ignorance and the wealth of learning. The pursuit of knowledge invites and persuades, nay, with sweet and resistless power, forces him to look upwards, convincing him that, if he look down, his shoulders stoop; that, if his thoughts be downwards, his character bends; and that it is only when he holds his head up, his body becomes erect, and only when his thoughts go upwards, his life becomes upright.

The pursuit of knowledge implies that tender yet firm discipline which guards our homes and guides our youth, which shows itself not only in words, but in all the circumstances of action. It is like an under agent of Providence, directing us in all the ordinary concerns of life. More shining qualities are there, indeed, than discipline, but none more useful, for it is discipline which imparts value to all the rest, which sets them at work in their proper times and places, and turns them to the advantage of their fortunate possessor. Without it learning is pedantry and wit impertinence: virtue itself appears in the garb of weakness; the best parts qualify a man only to be more sprightly in errors and active in his own undoing.

No: there is no discipline without industry, no industry without study, no success without incessant study. He who, from day to day, recognizes, said an ancient philosopher, what he has not yet, and from month to month what he has attained to, may be said to love to learn.

Love of learning is the characteristic of true manhood; and true manhood, whether found in the humble shop of the artisan, in the stately hall of the legislator, or the

gilded palace of the monarch, ever enlists respect, for its mouth never ceases to speak of wisdom, and its heart never fails to muse of understanding.

Give us men, cries out the state; give us men to guide our families, to lead our armies, to inspire our legislatures!

"Out of every youth that cometh unto me and gathereth wisdom at my feet," quoth the good angel of study, "I make a man," a man in truth, of whom may well and truly be predicated the immortal lines of the deathless bard of Avon:

The elements so mixed in him, that Nature might stand up
And say to all the world, This was a *man* '

SOCIAL BARRIERS REMOVED.

IT WAS the immortal Abraham Lincoln who said, "If you intend to go to work, there is no better place than right where you are; if you don't intend to go to work, you cannot get along anywhere."

The life of the great emancipator emphatically proved that his practice agreed with his preaching. His, assuredly, was a life in all its varied phases, in its every stage of progress, ennobled by work. It was work, persistent and purposeful, which led Lincoln from the drudgery of the frontier farm to the country store; from the country store to the law office; from the law office to the legislature; from the legislature to congress; from congress into the inner temple of the people's heart, and thence to the presidency of the nation.

How exactly the words of the prince of dramatists apply to Lincoln:

"Let him be but testimonied in his own bringings forth, and he shall appear to the envious a scholar, a statesman, and a soldier."

"Did you ever think," once wrote Everett, "why it is that so many of the great men of our country are found among those who began life in hardship and poverty? Many of them grew up in what was, when they were young, the western frontier, where they had to work hard; where they had no schools and few comforts and conveniences. They have come from those circumstances that seemed so discouraging, and have become presidents, judges, generals, or millionaires. You would find it interesting to put down the names of those who have reached such success from such hard beginnings, and keep a list of them. If you are careful to learn about such persons, and to write down their names, you will be astonished to see how long your list will become."

Work has been the key to the success of the men just referred to; it is, indeed, the key to all success. Looking over the antecedents of England's eminent men, we are forced to the conclusion that the intellectual giants of the Britain of our day, at least, come from the middle classes, and that a son rarely distinguishes himself in the same direction as his father. More than half the Lord Chancellors of England during the past fifty years were sons of poor men. One of them was the son of a country barber, and the father of another a Newcastle coal heaver.

The army and the law, in their topmost strata, owe little to the aristocracy, while the latter has no part at all in leading English men of letters.

The bar has a fair percentage of titled members, but the bench is chiefly recruited from the middle classes, and from every representative grade thereof.

Of the two living men who have sat on the woolsack, Lord Halsbury is the son of a doctor of laws, and Lord Herschell of a dissenting minister.

Sir Francis Jeune is a bishop's son, and Sir Walter Phillimore's father was a baronet. England's remaining judges come without exception from the professional and business classes, or are sons of country gentlemen, or country squires.

In the army the story is the same. Lord Wolseley's father was a major, Sir Evelyn Wood's a clergyman (and baronet), General Harrison's also a parson, Sir John Lintorn Simmons' a captain of artillery; while Generals Sir George White, Sir Edwin Markham, Sir Charles Wilson, Sir Redvers Buller, and many others of England's best known soldiers, are the sons of country gentlemen.

Of the archbishops, Dr. Temple, of Canterbury, is the son of a major, and Dr. Maclagan, of York, of an army doctor, both prelates, strangely enough, being of military origin.

Among leading English politicians, we naturally find many wearers of titles, but many of Britain's ablest statesmen spring from the middle social stratum. Mr. Chaplin is a parson's son, Sir H. H. Fowler and Lord Herschell come from the "Manse," Mr. Chamberlain from commerce, Mr. John Morley from medicine, and Mr. Arnold Morley from a city warehouse. Mr. Long and Mr. Balfour spring from the squirearchy, Sir William Harcourt from the church, Mr. Asquith from business, Mr. Bryce from the law, and Mr. Sidney Buxton from the House of Commons.

In the world of writers, however, we find the greatest diversity of origin. Mr. Blackmore is a clergyman's son, as are, also, Mr. Anthony Hope and Mr. Cutcliffe Hyne, while Mr. John Davidson, the poet, is the son of a minister. Mr. Marion Crawford is a sculptor's son, Mr. Herbert Spencer the son of a schoolmaster, Dr. Conan Doyle of an artist, Mr. Rider Haggard of a barrister and Norfolk squire, Sir Edwin Arnold of a Sussex magistrate, Mr. "Ian Maclaren" of a civil servant, Mr. Rudyard Kipling of a gentleman in the Indian educational service, Mr. Clark Russell of a singer and composer, and Mr. William Watson, the poet, is a farmer's son.

In a country like England, with rigid class distinctions of centuries' duration, no man can hope, without toil and study, to rise from the humbler ranks of society. The man of humble origin who thus rises in such a country to a position of eminence surely calls for commendation and invites imitation.

A WORKER ON WORK.

"SUCCESS," not long ago said Senator Francis E. Warren, of Wyoming, "is the attainment of that which we are striving for, and I think that every thoughtful man will agree with me in saying that the only road to it is work—hard, grinding, persevering, unceasing work."

Born of excellent New England stock, at Hinsdale, Mass., in 1844, the future senator was, in early youth, sent to the country school in winter, and helped on the farm in summer, till at eighteen he enlisted in the army, where he remained three years. Hostilities over, he returned to Massachusetts, but was immediately after offered a position in a furniture establishment at Cheyenne, Wyoming. With firm faith in the west as the young man's sphere of hope, he accepted the offer. His first years in Wyoming proved his inherent worth and belief in work. General-utility clerk, he slept in the store, his bed under the counter, his toilet arrangements a tin washbowl in an iron frame, at one end of the apartment. These inhospitable surroundings did not, however, discourage him. He applied himself to his work year after year, with all the assiduity he could command, devoting such spare moments as he could snatch from business to useful reading and study. He thus became the indispensable man of the establishment, a little after became a partner, and now owns the whole business. He is, besides, president of the leading bank of Cheyenne, owning its gas and its water plant, and having large farm and stock interests throughout the state.

Senator Warren's political advancements have been quite as marked as his business successes. Elected, not long after his arrival there, mayor of Cheyenne, he afterwards became member of the territorial legislature, sitting, in turn, in both chambers. Having, besides, served three terms as treasurer of Wyoming, he was, by President Arthur, appointed its governor. Removed by President Cleveland, he was reappointed by President Harrison, and in 1890, when Wyoming entered the Union, elected to the United States Senate, where he is now serving a second term.

That Senator Warren, even in this prominent position, places due value upon work as a factor of success, is evident from his remark, "If you look over this floor," waving his hand toward the senate chamber as he spoke, "I think you will find what I have just said is true of the majority of the men there. Those who have influence, those who figure on important committees and conferences, are those who have shown their capacity for work, and hard work, too, and long hours, and just about every day in the week. And so, when you ask me what brings success, I think I may safely say that, while there are a thousand different goals which are termed success, there is but one road, which leads to all of them, and that is the road of work."

The excellence of work was proclaimed by Phillips Brooks when he declared, "The man who knows, indeed, what it is to act, to work, cries out, 'This, this alone is to live.'" And more than two centuries before the gifted bishop of Massachusetts, the immortal John Milton had sung:

> Man hath his daily work of body or mind
> Appointed, which declares his dignity.

THE SECRET OF SUCCESS.

HOW often we see those born with the same advantages of fortune not equally prosperous in the course of life! While some, by wise and steady conduct, attain distinction in the world, and pass their days with comfort and honor, others of the same rank, by mean and vicious behavior, forfeit the advantages of their birth, involve themselves in much misery, and end in being a disgrace to their friends and a burden to society. Early, then, should our youth acquire the discipline of study, that they may

learn that it is not on the external condition in which they find themselves placed, but on the part they are to fill in life, that welfare or unhappiness, honor or infamy, depend. One of the first lessons that study imprints on the mind of youth is that happiness is a roadside flower, blooming only by the trodden highway of industry.

When youth enters on the achievement of its life work, what can be of greater moment than the regulation, with the most serious attention, of a plan of conduct to prevent any fatal or irretrievable error? If, instead of exerting reflection for this valuable purpose, a young man deliver himself up, at so critical a time, to sloth and pleasure; if he refuse to listen to any counselor save humor, or attend to any pursuit except amusement; if he allow himself to float loose and careless on the tide of life, ready to receive any direction which the current of fashion or the fury of passion may chance to give him; what may be expected to follow from such beginnings?

Can success be attained without the preparation, or dangers escaped without the precaution required of all men? Shall happiness force itself upon the undisciplined and unindustrious young man, and solicit his acceptance, when to the rest of mankind it is the fruit of long cultivation and the acquisition of labor and care, the reward of unremitting study?

Happy indeed is that youth who, unembarrassed by vulgar cares, spends his time in acquiring knowledge, who thinks himself not a complete man till his understanding is beautified with the valuable furniture of knowledge, and buttressed by the immovable supports of mental culture. There is, in truth, no success without happiness, and there can be no happiness without knowledge—the richest adornment and surest safeguard of the human soul.

THE BREADWINNER'S HALF HOUR.

THE breadwinner, to pursue a course of studies successfully, must be in a position to take up these studies whenever convenient, and lay them down when necessary. If he have, for instance, a half hour of leisure during the day, let him put it to the profitable use of study. Nor should he in dressing, or in a long ride or walk, waste the valuable hour succeeding his evening meal, when he is in best condition for effective mental work. Few men, till they have tried it, can realize what a vast amount of work may be done in the hour, say, from 7 to 8 P. M., often aimlessly spent in getting ready to go out for no useful purpose. The workingman should, after his evening hour or two of study, be at home, to seek, without further fatigue, his needed night's repose.

There are, of course, people who will say that they have no time for study. In reply, we may, with fullest and strongest emphasis, declare that there is no occupation that does not give some time every day which by an industrious and ambitious man may be seized on and devoted to study.

There are many notable instances of education obtained in time usually wasted. Humboldt had so little time for study that he read in the night or early morning, while others were asleep. One of the most noted mathematicians in the United States acquired his education by devoting one hour a day to study. Millard Fillmore never saw a grammar or geography until twenty years of age, yet he became president of the United States. Lincoln, while working at surveying, studied law, and while employed in a general store learned the rudiments of English.

Abraham Lincoln was a farmer's son, born and raised amid the poorest and most unpromising surroundings. Yet, in point of scholarship in the majestic mother tongue of our race, apart altogether from his unrivaled distinction as a statesman, Lincoln, the poor farmer's boy, became one of the greatest this or any age has witnessed.

A copy of the following letter of the martyr president written to a Mrs. Bixby, of Boston, has been engrossed, framed, and hung in one of the halls of Oxford University as "a specimen of the purest English and most elegant diction extant":

DEAR MADAME:—I have been shown in the files of the War Department a statement of the Adjutant General of Massachusetts that you are the mother of five sons who have died gloriously on the field of battle. I feel how weak and fruitless must be any words of mine which should attempt to beguile you from the grief of a loss so overwhelming. But I cannot refrain from tendering to you the consolation that may be found in the thanks of the Republic they died to save. I pray that our Heavenly Father may assuage the anguish of your bereavement, and leave you only the cherished memory of the loved and lost, and the solemn pride that must be yours to have laid so costly a sacrifice upon the altar of freedom. Very sincerely and respectfully,

ABRAHAM LINCOLN.

Robert Collyer laid the foundation for his education while working at a blacksmith's forge. Watt, as is well known, learned chemistry and mathematics while pursuing his trade as an instrument maker, and George Stephenson studied arithmetic while running an engine, night shifts. He educated himself, and did much of his best work during spare moments.

Then there are sometimes opportunities for study while at work. Workmen should take advantage of and strive to get these opportunities. Gazing vacantly for hours at machinery fulfilling its task is not the essential requisite of good work. That man is rendering his employer most efficient service who, while doing his work as he ought, fits himself for service of a higher order. That workman who reads and studies most, is the most competent of his class, draws the highest pay, calls for and receives the most respect.

Workingmen, no matter how employed or whatever may be the rules with regard to idle time while on duty, should remember that it has been men and women most crowded with work who have done the greatest things in life, and that waste of time for those whose only hope of advancement lies in education means loss of opportunity and loss of life's purpose. That man is yet unborn who rightly measures and fully realizes the value of an hour.

NEVER TOO OLD TO LEARN.

DISRAELI, in his "Amenities of Literature," tells us that there has been no old age for many men of genius; to which Longfellow, with his own incomparable persuasiveness, adds,

For Age is opportunity no less than Youth.

And Lord Lytton, in his turn, pays tribute to advancing years, when he so charmingly declares: "The old age of a great leader gathers reverence as an oak gathers moss."

If smiling spring invite to tenderness, love, and hope, summer and autumn present to wayfaring man charms that are equally irresistible. Of these latter seasons, Thomson sweetly writes:

Then comes Thy glory in the summer months,
With light and heat refulgent. Then Thy Sun
Shoots full perfection thro' the swelling year:
And oft Thy voice in dreadful thunder speaks;
And oft at dawn, deep noon, or falling eve,
By brooks and groves, in hollow whisp'ring gales.
Thy bounty shines in autumn unconfin'd
And spreads a common feast for all that lives.

If youth, the springtime of life, be specially adapted to study, the years of a man's maturity, its summer and autumn, ought to be the season of that study's growth and the harvesting of its valued products.

No man is ever too old to learn, and no limit can be assigned to the age when a successful course of study may be taken up. A boy's brain does not obtain its maximum size until he is about sixteen years of age, and does not mature until he is twenty-five. A man's physical powers do not ripen until he is about thirty-five, and eminent authorities believe that he does not attain his intellectual prime until forty-nine or fifty years of age, and that his best years for study or work are those after his fiftieth birthday.

Izaak Walton after eighty-five wrote some of his best works. Hobbes at eighty-seven translated the "Iliad." Bishop John H. Vincent, Chancellor of the Chautauqua Schools, has long and justly claimed that the best time for a man to study is from thirty to sixty, and the careers of Gladstone, Bismarck, David Dudley Field, Senators Edmunds and Sherman, and a host of others, prove that the period of highest usefulness may not be reached until a man has passed his seventieth or even his eightieth birthday.

A notable instance of what may be accomplished through study, by a man of advanced years, is to be found in the famous Judah P. Benjamin, who succeeded in achieving distinction both in Europe and America.

He was born in St. Croix, West Indies, in 1811, while his parents, who were English Jews, were on their way from London to New Orleans. His boyhood was spent in Washington, D. C., and in 1825 he entered Yale College, but owing to lack of funds was compelled to leave after three years. He studied law and began practice at New Orleans, teaching school at intervals. Ere long, recognized as a leader of the bar, he became a partner of John Slidell, who also won fame during the civil war.

His influence in politics began about 1845, but it was not until 1852 that he held office. Elected in that year to the United States Senate, his ability very soon gave him a prominent place among Southern Democrats. He was an ardent champion of slavery, and one of his speeches drew from Senator Wade the remark that Mr. Benjamin was "a Hebrew with the principles of an Egyptian." Not long after this the Jewish statesman had a personal encounter with Jefferson Davis, and there was talk of a duel, but it was averted when Davis made an apology on the floor of the senate.

When Louisiana seceded, Benjamin and

his colleague, John Slidell, formerly his law partner, left the senate, and, on the formation of a provisional government of the Confederate States, Benjamin was appointed attorney general, and in August, 1861, transferred to the war department. Having been accused of incompetence and neglect of duty by a committee of the Confederate Congress, he resigned his position, but immediately became secretary of state, which place he held until the overthrow of the Confederacy. He had the reputation of being "the brains of the Confederacy."

It was his habit to begin work at 8 A. M., and he often stayed at his desk eighteen hours continuously. All important questions came to him for an opinion. On the fall of the Confederacy, he fled from Richmond, with the other members of the cabinet, and on becoming separated from the rest in Florida, took an open boat and escaped to Nassau, in the Bahama Islands. Thence he went to Liverpool, followed by his wife and daughter, and, being without more means than needed to supply himself and family with the necessaries of life, studied English law.

Admitted to the bar at the age of 55, he soon attracted attention, and after a few years was made a queen's counsel. He now became one of the most eminent and successful lawyers in Great Britain. Riches flowed to him. For ten years he appeared solely as counsel in the House of Lords and the Privy Council. His wife and daughter lived in aristocratic splendor in Paris, and he spent much of his time with them. In 1883, when he gave up practice, the bar of Great Britain and some of the most eminent of aristocrats gave him a farewell banquet. He went to Paris and died in 1884.

We have, at this very moment, that great statesman and gifted diplomatist, as well as finished orator and author, Lord Dufferin, the greatest Governor General that Britain has ever given Canada, beginning, at the age of 72, the study of the Persian language.

A beneficent Creator has introduced us into a magnificent world. Here we are spectators of the Divine wisdom and works, and have ready access to all the comforts which nature, with bountiful hand, has poured forth around us. Can years of maturity be better spent than in strengthening the mind by study of God's works, and of man's achievements blessed by an All-wise Maker?

If the opportunities of youth have been neglected, are not those of summer and autumn to be put to profit?

If the dawn of day has been passed in sloth, shall not the glorious noontide or peaceful eventide be employed to retrieve the losses entailed by earlier indifference and lack of industry?

Age, no less than youth, has its duties and its opportunities. The duty of every man, old or young, is to profit by opportunity, never forgetting the dictum of Smiles, "Whoever strives to do his duty faithfully is fulfilling the purpose for which he was created."

SELF-EDUCATION.

EVERY educated man is, justly maintains Eggleston, in some sense, self-educated. No teacher, however transcendent his abilities, can force an education on an unwilling pupil. Neither can any teacher educate a persistently idle pupil. The teacher can bridge over difficulties; he can point out the way; he can advise and direct; he can stimulate the student to activity; but the real work, if done at all, must be done by the student himself.

COURAGE THE PARENT OF ENERGY.

"THERE is," says Bushnell, "a great and lofty virtue that we call courage, taking our name from the heart. It is the greatness of a great heart, the repose and confidence of a man whose soul is rested in truth and principle." Courage is the parent of energy, and energy, in turn, the mother of activity.

Gray hairs are venerable not because of ease and inactivity, but because of noble achievements, prompted by courage and directed by energy.

Not alone in the world of literature, or in that of statesmanship, do we revere the energizing influence of honorable ambition and masterful, courageous activity in old age. The world of industry presents us with many instances of age made doubly venerable by the active pursuit of objects at once useful and creditable.

A striking example of a busy old age is that of William Deering, proprietor of the famous harvesting machines, the largest manufactory of this kind in the world. Mr. Deering tells us that the turning point of his life was what he terms a kind of accident.

"I loaned a man making reaping machines some money," he says, "and had to become

a member of the firm to protect my interests. I bought him out in 1878, and a month later my shops were destroyed by fire. The following year was a busy one, seeing that I had to rebuild my factories and make machinery for building the reapers. And to add to the predicament, I did not know one reaper from another when I took hold of the business. Our goods sold well, and in 1880 I purchased thirty-five acres of ground on the present site in Chicago. This spot was then far away from the city and surrounded by brickyards. The nearest railroad was three-quarters of a mile distant. The factories now occupy sixty-two acres, and employ from three to five hundred hands."

In answering the question, to what methods or qualities he considered his success due, Mr. Deering replied: "I do not know that my career can properly be called successful, but whatever I have accomplished has been achieved by attention and application to the work in hand, and by honest, honorable dealings always." "Is there not another more particular reason?" was asked. "Well, I think," said Mr. Deering, "that this fact has had as much to do with it as anything. We have been on the lookout for new improvements, whether they originated with us or with others. We have not shunned new ideas. We have led in making progress in our business. We were the first to put the harvester on the market, which took the place of the old reaper. We were the first in the field with the wire binder; in fact, with no exception, we have led the procession of harvesting machines in the line of inventive improvements. In this fact lies one of the chief secrets of any success we have achieved. It was my intention, early in life, to become a physician."

Though Mr. Deering is seventy-nine years of age, he is still strong and hearty. He works daily in his office with the vigor and enthusiasm of youth.

A life such as that of Mr. Deering should inspire us all with the same courage which has been the mainspring of its success. Headley, speaking of the great Napoleon, states that "Whenever a column saw him at its head, they knew that it was to be victory or annihilation." Men of courage are at our head. Shall we not, under their lead, achieve victory, carrying out to the letter the noble and inspiring counsel of Horace Mann: "I beseech you to treasure up in your hearts these, my parting words: Be ashamed to die until you have won some victory for humanity."

SCHOOLED BUT NOT EDUCATED.

THE shores of life's troubled sea are strewn with the wreckage of ruined lives.

Ask we the cause of such widespread and lamentable disaster, and we are told that it is the result of unrestrained passion. If there be, indeed, any fertile source of mischief to human life and defeat to human purpose, it is, beyond doubt, the misrule of passion, which poisons the enjoyment of individual men, overturns the order of society, and impedes the path of life with so many afflictions as to render it in truth a very vale of tears.

Most of the great scenes of public calamity, beheld with astonishment and horror, originate from the source of violent, ungoverned passions. The earth they have drenched with blood, the assassin's dagger they have pointed, the poisonous bowl they have filled. For the declamation of the orator and the tragic song of the poet, they have, in every age, furnished too copious material.

In individual life, passion taints the soundness, and troubles the peace of that mind over which it reigns; fortune it wastes, health it destroys, character it debases. It leads, in a word, to ruin—complete, overwhelming, and irretrievable. But, ascribing to passion all the responsibility thereto attaching for wrecked hopes and ruined lives, much of the wreckage and ruin, darkening and encumbering the shores of the great ocean whose waters bear the burden of so many millions of human lives, cannot be accounted for, unless we ascribe it to misdirected education.

We read in "The School Journal" of an American who lately wrote that the driver of his hansom, in London, was a graduate of Oxford University. There are, no doubt, many graduates of that famous university unable to earn a living in any higher sphere of activity. Many young men come out of college *without* an education. They know something of Latin and Greek, have read some history, and perused, perhaps, some volumes of classic English literature, but having received no useful or purposeful training are unable to claim rightful place in the civilization that surrounds them.

What is true of the college is also true of the high school and even the advanced school. A recently published statement of the results achieved by the Providence (R. I.) high school is here in order.

A period of one generation of 33 years is covered, the record embracing those boys

who entered the school from its opening in 1843 up to 1875, inclusive. Mr. Hoyt says in his report of the results of his investigation of the subject: "Within this period about 2,000 boys entered the school. Of these 63 are known to have died young, before entering upon any regular calling, and probably the real number is considerably larger. *Seven hundred and ninety have not yet been traced*, leaving 1,138 whose occupations have been determined."

This proportion holds good everywhere.

Is it any marvel that, with more than one-third of the graduates of high schools unheard of and untraced, there should be such a growing and strenuous demand for technical and industrial education? In obedience to this widespread, emphatic, and irresistible demand of our age and country, a stately, stout-timbered, and well manned ship, International Correspondence Instruction, has just left the capacious haven of education, to lend assistance to every tempest-tossed bark on life's stormy wave. Fewer wrecks will now strew the coast, sadden the heart, or darken the life of humanity.

PRIVILEGES OF THE EDUCATED.

THE privileges of the educated are inestimable. They know more, feel more, see more, accomplish more, and live more happily than the uneducated. Would you have this world beautiful? Learn what is beauty and find it everywhere. Would you enjoy the higher life? Ascend the heights of opportunities put to profit, and you will breathe a purer, freer, and holier atmosphere. The end of education should be to raise life higher and render it nobler, better, happier.

THE ACQUISITION OF KNOWLEDGE.

"IF," said Daniel Webster, "we work upon marble, it will perish; if we work upon brass, time will efface it; if we rear temples, they will crumble into dust: but if we work upon immortal minds, if we imbue them with principles, with the just fear of God, and love of our fellow men, we engrave upon those tablets something which will brighten to all eternity."

Diligence, industry, and proper improvement of time are material duties of the young.

The acquisition of knowledge is one of the most honorable occupations of youth.

Be determined to succeed. If you have great difficulties, cut your way with the diamond of studious application.

The diminutive chains of habit are generally too small to be felt till too strong to be broken.

"A man is," writes Emerson, "relieved and gay when he has put his heart into his work, and done his best; but what he has said or done otherwise shall give him no peace."

RUSKIN'S GOOD COUNSEL.

TOO many pupils leave school with an idea that they are prepared to obtain a livelihood without work: that because they have an education they should not be expected to work. The teacher or system of education responsible for a notion so erroneous is certainly wanting in educative qualifications. Pupils should be made feel that it is every man's duty to work up to his full capacity: that all men who have ever become truly great and useful are those who not only knew how to work but did work. Ruskin says, "Pleasure comes through work, and not by self-indulgence and indolence. When one comes to love labor, his life is a happy and contented one."

THE EDUCATOR A MISSIONARY.

INDIFFERENCE and lack of appreciation of the high ideals of life stand in the way of individual effort. Ignorant of the blessings of an education, and seeing but little of its true character and effect, the great mass of ignorant people are not stimulated by their own desires and ambitions to personal endeavor. Parents, often failing themselves, for lack of development to appreciate education, are content to allow their children to live the same lives of darkness and drudgery fallen to their own sad lot.

The faithful educator, with trained hand, head, and heart, is truly a missionary, as he enters the home and hearts of a discouraged and ignorant populace, and kindles into flame the spiritual and mental life of children and parents alike.

"There are," justly remarks Charles Kingsley, "two freedoms—the false, where a man is free to do what he likes; the true, where a man is free to do what he ought."

Life is an arrow. You must therefore know what mark to aim at, how to use the bow, then draw it to the head and let it go.